Chapter 1

The Semantic Environment of Science

If it dies, it's biology, if it blows up, it's chemistry, if it doesn't work, it's physics.
—John Wilkes, as quoted from graffiti on a bathroom wall.

During your work with the sciences in graduate school and in your subsequent career, you find that a great percentage of your time is spent writing papers and making presentations. Scientific communication is essential for helping us use and take care of this earth. To keep ideas alive, researchers who discover the wonders of science must tell someone about their findings in clear, complete, and concise terms. To add to the pool of scientific knowledge, research scientists must synthesize other available information with what they discover. If any scientist uses poorly chosen words, omits important points, or fails to understand a given audience, messages can become unclear or misinterpreted, and the progress of science suffers.

Before we get into a discussion of scientific papers and presentations, let's be sure we are not harboring a common misconception about scientists. When one utters the word "scientist," for many people the image that comes to mind is the research scientist exploring in a laboratory or the field for new discoveries in science. Certainly that person is a scientist, but think beyond that image. Careers for scientists also include many things besides research. There are practitioners who apply the scientific discoveries, consultants who advise non-scientists, the science educator who teaches science students, journalists who write about science, the science librarian or museum curate who oversees a collection of scientific materials, the sales representative who demonstrates scientific products, the science lobbyist whose job is to explain the needs of science to politicians, the horticulturalist who tends a botanical garden, and numerous other specialists.

Not all these people may have degrees in science or consider themselves scientists, but all must deal with scientific communication. Some may have doctoral degrees, some masters, some bachelors, and some may not have science degrees but have acquired enough science background to write or speak about science. They need to communicate with each other, with clientele, with students, with the general public, or with their particular audiences.

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The material in the following chapters is for all who find that communication about science is primary to their careers. At some points, I concentrate on the communication specific to the research scientist, the science writer, or another audience, but almost every chapter contains fundamentals of communication common to all of us.

No special talent is required nor is magic involved in clear scientific communication. It is simply a skill developed in semantics, or in exchanging meanings with words and other symbols, within a social and scientific environment. To be successful, meanings associated with those symbols must be nearly the same for both the sender and the receiver. But either the author or the audience can manipulate meanings, and being human, both probably will. Communication is the vehicle that carries information and progress in a culture, but it also carries disputes, misinformation, and disruption of progress. Generation gaps, wars, and prejudices result, at least in part, from something communicated or not communicated. On the other hand, bridges across generation gaps, peace, and understandings as well as fantastic discoveries in the sciences are also results of communication. In scientific communication, be ever wary of the human elements and communicate as concisely, conventionally, and clearly as you can with your audience in mind.

Writing or speaking about scientific research is no more difficult than other things you do. It is rather like building a house. If you have the materials you need and the know-how to put them together, it is just a matter of hard work. The materials come from your own study and research. Any attempt to communicate in science is fruitless without quality material or content. Once ideas and data are available, you put them together with the basic skills of scientific writing or speaking. The hard work is up to you.

In any sort of work, you must learn the names of the tools you use or how to operate the instruments in the manufacturing plant, the lab, the construction site, the field, or the office. You must learn what care has to be taken with equipment and with data, or else you should not be working in science (Figure 1.1). Whether it is an ax or an autoclave, equipment can be dangerous, and so can words. Writing or speaking, like chemistry or biology, requires cautious, skillful work with the tools available, and understanding of the content and premises on which messages are based.

But more so than constructing a house or carrying out scientific experimentation, communication contains much of the human element and is far more subjective than science and less reliant on empirical data. Thus, to work with communication, you have to recognize that it emerges from the individual human into a social context where it can become either clarified into meaning or polluted into confusion. That means that no formula exists for communication, and what you say or write is modified and tempered by your own personality and belief. Its reception depends on the audience and the other elements in the semantic environment in which you deliver the message. The major objective is to get whatever the speaker or writer intends or **means** to

FIGURE 1.1 Learn to take care of science equipment and data, or you should not be working in science. *(Cartoon from Andrew Toos [July 1, 1992].* The Chronicle of Higher Education. *Used with author's permission.)*

an audience with the same interpretation or **meaning**. That is what semantics is all about—the relationship of meaning to words, physical expressions, and other symbols used to communicate.

1.1 THE SEMANTIC ENVIRONMENT

I use the term "semantic environment" frequently in this book. I picked it up from Neil Postman in his *Crazy Talk, Stupid Talk* (1976), a book I recommend that every educated individual read. Unfortunately, it is out of print, but if you cannot discover a used copy, read another of Postman's books. Any of them will teach you more about language than I ever can. As I use the term semantic environment, which Postman suggests originated with George Herbert Mead, I am likely to add my own flavor to make it a semantic ecosystem even more ecological and applicable to a discussion of the environment in which the language of science is written and spoken. At any rate, it is one of those tools that I use here to try to provide you with suggestions on how better to communicate in science; therefore, let me expound on it a bit more from my point of view.

The concept of the semantic environment is what makes many of us frustrated when a statement is taken out of context. Again, I agree with Postman in that the environment or situation in which words are spoken is essential to the meaning of those words, and any element in that environment can alter a meaning. I like his analogy of pouring a drop of red ink into a beaker of water

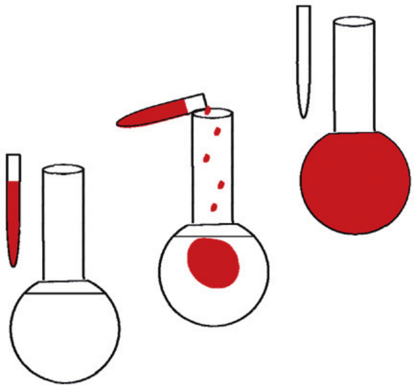

FIGURE 1.2 Unwanted elements in the semantic environment can color an entire communication effort.

with the result that all the water in that beaker is now tinted with red (Postman, 1976) (Figure 1.2). Let's take that analogy outside the lab to a biological ecosystem. Every organism in that ecosystem is influenced by every other organism as well as all the other chemical and physical matter in that environment. The efficacy of the organism relative to its vigor and proliferation depends on the extent to which it can thrive in that environment. Impositions on the environment can inhibit or aggressively proliferate invasive species within the ecosystem. The same context can describe your communication efforts; intended meanings can be destroyed or inhibited, and false meanings can proliferate.

The success of your communication will depend on how well you respond to the multitude of elements in the semantic environment. For example, suppose you are to make a presentation at a meeting of scientists familiar with your field. First and foremost, the environment is scientific and carries the semantic elements of a physical setting, tone, attitudes, passions, atmosphere, and purposes of science as clearly distinguished from the situations Postman describes for the semantic environments of such things as religion, business, war, or lovemaking. As he suggests in *Crazy Talk, Stupid Talk* (1976), "A semantic environment includes, first of all, people; second, their purpose; third, the general rules of discourse by which such purposes are usually achieved; and fourth, the particular talk actually being used in the situation." However, the semantic environment for your speaking situation or setting is also made up of a plethora of other smaller influences, including the size of the room, the temperature in the room, how many people are in your audience, who they are, what is in the mind of each, how much you and your audience know, how well prepared you are, and what kind of equipment or images you have for displaying visual aids, as well as the words or other symbols you choose to express yourself and what arrangement and with what tone the words come from your mouth or your keyboard. Of course, these are just a few of the multitude of influences in your semantic ecosystem, but the extent to which you can

successfully use the influences that will support you and modify or resist those that deter your efforts is the extent to which you will be successful.

Maybe some of your success will depend on your turning the thermostat down a bit so that the audience is not sweltering, or shutting the door so that the noise pollution from outside does not enter the environment. A noisy late comer into the room may color the waters like the red ink, but you may be able to clear the medium by attracting audience attention back to you and your message. The semantic environment can be totally destroyed if the late comer yells, "Fire, the building is burning down. Get out." You need not try to preserve the environment at that point, but simply direct the audience to the nearest exit and get there yourself. Except for such extraordinary disturbances, you have a great deal of control over the semantic environment, and with you as the central focus in the room, you can preserve the environment or destroy it yourself with the way you handle the various elements. What I would like to do with this book is to help you avoid destruction and to go beyond the simple preservation of that environment to success of your communication efforts throughout your career.

For this communicative organism, which is **you**, to survive and succeed in this semantic ecosystem depends on your understanding of the environment and your practicing good communication skills. If you do not want to be the spindly little weed among the giant redwoods of science, develop your communication skills as well as your scientific expertise. Developing communication skills requires a combination of mental and physical activity. Like any such activity, it requires regular exercise or practice to move toward perfection. With swimming, you cannot simply let someone tell you how, follow those instructions, and win a national title the first time you swim. The same is true with writing or speaking; only with continual practice can you develop and maintain the skills you need. Once you feel comfortable with those skills, you may even enjoy writing and speaking to an audience. At least you will be a healthy organism among your peers in this semantic world of science.

1.2 BASIC SEMANTIC ELEMENTS IN COMMUNICATION

You have been in school for many years; you know how to talk and write. You may or may not have had much of the needed practice in scientific writing, but you probably have had all the grammar and rhetoric courses you want. Do not disparage those courses. Basic instruction in the use of language is a good foundation for writing and speaking as long as you do not let that instruction inhibit your communication. Sloppy grammar, punctuation, and spelling can be highly distracting to a scientific message. But this text does not presume to instruct you on points of grammar and basic composition but, rather, on giving clear meaning to content and achieving your purpose in scientific communication with producing, reviewing, evaluating, and revising and disseminating papers and presentations. Those tasks can be easier as you define your purpose in communicating and develop guidelines that will work for you.

Any communication, and especially information exchange between scientists, is a matter of asking and answering questions. In scientific communication, asking the questions is the foundation for discovery; providing answers to your colleagues and to future generations adds knowledge to knowledge and keeps scientific progress alive and well. From "How are you?" or "What's happening?" to "Does a virus or a bacterium cause the disease?" or "How great is the threat of global warming?" the questions form the foundation for communication. Questions are in the minds of any audience, and answering a question even before it is asked often averts many problems. If someone did not wonder about answers, science would be in real trouble. As you consider a paper or a speech for your fellow scientists, try to determine what questions are in their minds and yours and which ones you can and should answer.

All forms of scientific communications have a great deal in common but differ with the semantic environment. Variations in content and organization are imposed by the questions from different audiences and the answers you give. An audience of sixth graders will not ask the same questions that scientists in your discipline will ask, but you can cover the same subject for both groups. In communicating about your work as a scientist, content and organization are clearly influenced by scientific methods of inquiry and reflect recognition of a problem, observation, formulation of a hypothesis, experimentation, collecting and analyzing data, and drawing conclusions. Notice that each of these steps poses a question that your research and then your communication seek to answer. What is the problem? What do you observe about it? What do you hypothesize? How do you experiment or explore for a solution? What data will you collect and how will you test it? What conclusions can be drawn? The content of your scientific paper will involve some or all of these questions no matter who is in the audience, and the organization of your communication will be based on a logical progression of answers.

Another major influence on organization and content is the use of conventional techniques in scientific communication. An audience can understand you if you use familiar communication devices they understand and expect. For example, most organization in scientific communication, whether it is for journal articles, laboratory reports, or seminar presentations, uses the IMRAD format. The acronym IMRAD stands for Introduction, Methods, Results, and Discussion. For journal manuscripts, Silyn-Roberts (2000) adds an A to mean abstract so that the acronym becomes AIMRAD. These sections are the conventional or the expected order for most scientific papers. A few journals alter this formula and present results and discussion before methods. They are simply answering the question "What did you find out?" before "How did you find that solution?" That organization does not negate the convention; it just asks the questions in a different order. The IMRAD format is a common example of what is conventional or what the reader or listener expects.

Much of the expected we do without realizing we are following conventions. For example, in English the order we give to words within sentences is

generally the subject first followed by the verb and then its object. Notice that the first sentence of this paragraph does not follow that pattern. As a result, the sentence sounds a little strange, and it would perhaps be a better one if the order were conventional. Except for trying to call attention to a sentence or to emphasize a certain point, you should give the reader the expected. A major purpose in this text is to outline what is conventional for the forms of scientific communications. By no means do I discourage creative modifications to those conventions, but be sure the unexpected carries the audience along with it without distraction from your purpose.

Recognizing the semantics of science and the situation in which you communicate is up to you. In addition to the questions from a given audience and the conventions that have evolved in language, your success depends on knowing who that audience is, knowing your subject and purpose, and recognizing your own abilities and convictions. These are essential influences in the semantic environment of both written and spoken communication. You must be alert to these and the other elements of the semantic environment in which you communicate, and interact with whatever supports your communication while learning to resist or tolerate any pollution that enters the ecosystem. As you grow in your career as a scientist, periodically remind yourself about the fundamentals of your science and about the fundamentals of successful communication. Visualize your audience and consider your subject and your purpose for communicating. What questions will that audience ask and how can you best answer them? What media will best convey your message? Finally, every individual communicates differently; you need to think about yourself and your own capabilities.

To merge yourself with other elements of the semantic environment, think first of your **audience**. They are half the communication and most important to the interpretation and understanding of your scientific message. However hard you try to send a clear message, the completed communication rests with them. You cannot control an audience entirely, but because you are initiating the communication effort, you are responsible for presenting information that can be easily interpreted and understood. Never blame the audience for a misunderstanding until you have carefully critiqued your own efforts. To develop your skills, objectively think through and edit your own communications every time you write for or speak to an audience. **Understanding your audience and your position relative to that audience are crucial issues to the success of any communication.**

For most scientific papers and presentations, your audience may be scientists especially interested in your subject. However, you will need to communicate also with other scientists and with lay audiences. You may defend your thesis before scientists with relatively diverse interests. Your grant proposal may be going to a charitable, political, or business group that has no scientist on the staff. You may be trying to communicate with a publisher or an editor. You may need to transfer a new scientific discovery to those who can make

practical use of it but have little understanding of the science involved. Science practitioners often have to educate clients or the general public who have little knowledge of the scientific principles behind your work. Think in terms of how much experience and education the members of the audience have and what their motivation is for listening to you. Their attitudes and expertise can determine how you will present your subject. You will not make the same presentation to a group of oncologists that you will make to a group of cancer survivors even if the subject is the same. Chapter 19 offers more details in communicating with nonscientific audiences.

Regardless of their prestige and education, members of the audience are human, and so are you. Human beings are rarely logical, completely fair, or unemotional. No matter how much you try to keep scientific communication strictly factual and objective, the human element is present. For example, if you are making a speech, the audience will notice your appearance and your voice before they ever hear a word you are saying. When readers look at a page, they will notice appearance: the size of type, whether paragraphs are short or long, and whether there are headnotes or illustrations. People have certain expectations about how a speaker should dress and sound and how words on a page should look.

Once words are introduced, the reading audience or listeners have further expectations about meanings and patterns for those words. Most educated people expect standard English diction and sentence construction. If either is substandard or foreign to them, a break in communication results. Whether you are talking or writing, if you first give the receivers what they expect or what they find familiar, they can feel comfortable. You can then lead them to your point even if it is unexpected or unfamiliar. It is not always the meaning of words that matters as much as it is the way we hang them together and the semantic environment in which they are presented. No word has a fixed meaning nor can it be fully defined except within the context from which it is sent and how the audience receives it. **The extent to which a word or idea reaches the audience with the same meaning it had when it left the sender constitutes clarity in communication.**

Other components of communication to consider before you begin to write or speak are your **subject** and **purpose** in relationship to the audience. You have to be convinced that your subject is worthwhile, that the audience cares about it, and that what you are telling is accurate. For your own confidence, you need a clear purpose. *Conviction* is a key word that joins with *concise* and *conventional* in producing clear communication. After you are convinced regarding your message, the next job is to convince your audience. Almost any subject can be addressed to a group of scientific specialists or to third-grade science students, but not with the same words and techniques. Adapting to the audience will depend on how well you ally your subject with your purpose. Why are you writing or speaking about a certain subject? Obviously, several motivations stimulate your communication. Students often say their purpose

is simply to fulfill an assignment. Maybe your reason for writing a thesis is to get a degree, or you are writing a journal article or making a speech to get a promotion. Those are certainly good reasons to write and speak well. But surely purpose goes beyond those goals. A general purpose is the exchange of scientific knowledge; your specific purpose will depend on your subject and your audience. You may want students in plant breeding to know that cotton fiber initiation begins at anthesis. Once you define that purpose, you just need to develop ideas to answer questions that might be asked about that conclusion. The more specifically you define your purpose, the easier your task will be. When you have defined why you are communicating, your next job is how best to get your message across. The form your subject takes and the purpose you pursue will partly be determined by who the audience is. A main reason for always having someone review your work is to determine whether your subject has been adjusted to your audience.

With your audience, subject, and purpose in mind, remember that communication is essentially a question and answer format, but often the question is neither written nor voiced. Your communication will likely succeed if you are answering the same question that is being asked about your subject. That job may sound simple, but be judicious in deciding what questions to answer. The IMRAD organization for most scientific papers gives you the basic questions. You will tell what you did and why you did it in the Introduction, how you did it in the Methods section, what you found out in the Results, and what it all means in the Discussion. But there are questions within those questions, and it is difficult to get into the minds of your audience, and all their little questions can be frustrating. Why did you do it that way? Is that like the result that Jones got? Can you give me an example? These questions are not always obvious ones that would be asked or even directly related to your subject, but most of them deserve answers if minds in the audience are asking. Make your best effort to determine what questions the audience would want answered.

In addition to thinking about the purpose, subject, and audience and which questions they would ask about that subject, you also need to think about **yourself**. Attitude is as important in scientific communication as it is in all our activities and accomplishments. If you hate to write or speak, you will not do either well. If you love to communicate and find everything you write or talk about a true delight, you also will not communicate well in science. A scientific attitude of confidence but of careful self-scrutiny and a dash of humility can form the foundation you need for successful papers and presentations. Allow yourself to be creative, but keep an element of scientific control on your compositions. Success depends on simplicity.

You have to believe in what you are doing and what you are saying. Intelligence, education, and personality go a long way, but when you get down to the fundamentals of doing science and reporting it, you have to have conviction. This dedication can carry you far in science and always shows in your communication. Do not misjudge your audience. They can tell when you are

bluffing, when you do not care, and when you do not believe in what you are doing or saying. You can learn rules for communication; you may even be good at play acting. But without some ability, integrity, and sincerity, your efforts in communication will fall far short of excellent.

Notice how all the ingredients in communication are interwoven. I cannot talk about subject without discussing audience and purpose and author. Conviction and convention also depend on all those things. In fact, we understand any one of the major elements in communication only relative to all the others. This semantic ecosystem is interlaced with many co-dependent species and forces. That is what the semantic environment is all about. There are no fixed rules, but there are conventions. There are questions to ask and answers to provide. An interaction of author and audience with subject and purpose through technique will produce communication. In this complex of influences, develop the skills to keep it as simple as possible.

This text surveys the forms of scientific communication that a graduate student or a scientist will most likely encounter, and it suggests approaches to the most common problems associated with developing necessary skills. But all the instructions and good examples in the world cannot make you a good writer or speaker. A book may be able to tell you how to swim, but developing the skill and keeping the muscles toned for swimming are up to you. Above all, know how to keep your head above water or be able to come up for air when you need it. Your best source of information on those judgments is you. I hope this text is valuable in helping you to make critical distinctions between what is or is not effective in the scientific exchange of information.

My last plea for all scientists in this introductory chapter is that you never separate or isolate yourselves from the rest of us. That is, your responsibility to society is huge. Our daily lives in this present civilization are ruled as much by science as by government. The discoveries you make and what you do with them are sometimes matters of life and death and certainly our comfort and well-being. Speak to us in our language. And share the things we say. As Goethe said, “One should each day try to hear a little song, read a good poem, see a fine picture, and if possible, speak a few reasonable words.”

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Chapter 2

Before You Begin

He has half the deed done, who has made a beginning.

—Horace

Before you begin to prepare the paper or presentation, you should be alert to several components in the semantic environment of science that affect the communication: your attitude; your abilities to speak, write, and listen; the audience and the purpose; the scientific message; and techniques, tools, and sources that can be helpful.

We need a philosophy behind our communication because, as humans, we are willing to figure out how to accomplish goals if we know why. Perhaps our primary struggle as humans is to live, but a close second is the need to communicate with others, first with parents and then with family and friends, with teachers and peers, but also as scientists with scientists and other audiences. Along the way, we develop vocabularies and conventions for putting words or other symbols together so we will be understood. It is most frustrating and often destructive to say the wrong thing or to be misunderstood.

Enter human nature. Both the attitude of the speaker and the attitude of the listener, or writer and reader, are important to prevent misinterpretation. Attitude may be the strongest influence on what is communicated and how it is interpreted by an audience. We can hardly change our personalities, but we can adjust our attitudes and philosophies. Bad attitudes in scientists and others are often derived from such feelings as "Be impressed with me; I'm important." "I'm scared; feel sorry for me." "I have a poor background and will never be a good communicator." Or, worst of all, "My audience is ignorant and it's their fault if they don't understand." Sincere scientists believe in themselves and what they are saying, and they want to communicate that confidence to the audience but flavor it with a good dash of humility. Of course, the audience is somewhat ignorant of what you have to say or there would be no need for you to say it. The good attitude simply wants to be honest, objective, and clear in sending and receiving messages.

It is the responsibility of the speaker or writer to present ideas as clearly as possible to a given audience, but it is also a responsibility of a listener or

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reader to make an effort to interpret a message clearly and justly. As babies, we mispronounce words. "Wawa" may mean "water" or "I want a drink," and the parent will interpret accurately but may smile at the mispronunciation. We are often amused by inadequacies or differences in communication as children or persons from other areas of the country or other countries communicate in our vernacular. But our own colloquial language may be no better than that of others, and they may smile at the way we say things. It is good to be able not to take our linguistic foibles too seriously. It is destructive to belittle someone else's attempts to communicate or to use terminology you know they will not understand. Some in-groups will develop their own ways of saying things that are not well understood by others—for example, the street talk of some young people or the jargon of scientists. Such terminology can add to the language and our ability to express ourselves, or it can be destructive and lead to misunderstanding. Creativity can be good for the language; hiding meanings or reserving them for a particular group can be detrimental to society.

Communication is a vehicle for conveying ideas—a network like a nerve or blood system that flows through the body of humanity or the smaller environment of science. It can create or kill. If it flows smoothly, it carries civilization forward. In science, it pools knowledge on knowledge to afford us a background to find the answers to questions that our grandparents would not even have known to ask. If the flow gets clogged, it can completely disrupt a semantic environment. The sins of language, like other sins, can come with excess, omissions, dishonesty, ignorance, or malicious intent. It is a scientist's responsibility to guard against these forces. Respect for language is a serious matter, and miscommunication is dangerous. Enter here the world of science.

I have been repeatedly told that communicating in science is different from what the composition English teacher told us to do. I agree that science has differences, but the fundamentals of the language are the same. Involved in science is a different semantic environment with different people, purposes, general rules of discourse, some different vocabularies, and differences in the situation. The complexity of communicating in science is compounded by the fact that science must be precise and objective, and objectivity is difficult for human beings. Any communication is interpersonal, psychological, and social as well as objective and intellectual. Personalities must be involved so that with communication in science it is essential that one be as simple and exact as possible. For that reason, usually we need to follow conventions that are set forth, follow the same formats and techniques others use, and choose words precisely.

Nora Ransom's primary rule (see Chapter 3 for a complete list) for scientific and technical writing is "If it can be interpreted in more than one way, it is wrong." That is a strong statement, and we cannot always condition the audience to think exactly as we are thinking when we send a message, but as nearly as possible the scientist sending a message must put forth information in the most easily understood way, and the receiver of that message

must listen and interpret as honestly as possible. The progress of science is at stake. You will become more comfortable with scientific papers and presentations by knowing the conventions and tools for the various kinds of scientific communication.

2.1 KINDS OF SCIENTIFIC COMMUNICATION

The most common forms for scientific communications are reports, journal articles, proposals, theses, abstracts, speeches or slide presentations, poster presentations, and sometimes books, chapters, review papers, group communications, and writing or speaking for lay audiences. **Report** is really a catch-all term that includes everything from a laboratory account of a single experiment to progress reports and group reports on entire research programs and the consultant's or practitioner's report to clientele. Your chief interest in graduate school may be the graduate proposal, your first journal manuscript, and the thesis or dissertation as well as slide and poster presentations, but as a scientist, you will also become concerned with producing numerous reports, journal articles, grant proposals, collaborative reports, memos, and even chapters or books. As practicing scientists, some of you will find that your careers involve a great deal of writing or speaking to an audience of nonscientists. These messages are often called **science communication** rather than **scientific communication**. Chapter 19 provides a more detailed discussion of communicating with nonscientists. Acquaint yourself with all these forms and produce them with simplicity, precision, clarity, and always honesty. Your first attempts with scientific papers and presentations may benefit from some help. In this handbook, I can give you some fundamental ideas on the kinds of scientific communication, but I cannot go into a great deal of detail. I do, however, attempt to refer you to more detailed publications on the subjects in each chapter. Become familiar with other sources that can save you time and improve your communication.

2.2 SOURCES OF HELP

Your difficulty at this point may be that you do not know how to get started on these kinds of communication. The communication courses you took never required writing a journal manuscript or making a poster presentation. There is help out there. If you have had difficulty with writing, you may need to think about how to accomplish clear communication for anything. That is the subject of the first three chapters of this book. Several other good books are available on the subject. I recommend Zinsser (1998), but you can find others as well. Keep in mind that when I name sources here and throughout this book, the list cannot be definitive. Many books have been written on scientific communications and many more on all kinds of communication. If you do not find the one I suggest or if it does not fit your purpose, find another. Sources are not difficult to find, especially with electronic searches.

Browse on the electronic screen or the library bookshelves, but you may save time by first simply becoming oriented to what is available. Your own search can be made easier by noting the references cited in this or other books on scientific writing or speaking. Even before exploring those lists, collect information available through your graduate office or your department on writing theses, proposals, or other reports. If you are a student, ask for recommendations from your professors or librarians. In your career as a scientist, you may not have professors and librarians to consult and may find publications more helpful. Obviously, no one can read all that has been published on scientific communication, and you need to be selective. The sources in this and other chapters can get you started or perhaps lead you to the source you need. The following are simply representative of what is out there.

For success in graduate school, become familiar right away with the library services and computer databases for literature searches in your discipline. You can also become oriented to the graduate world by reading such books as Peters (1997), Smith (1998), or Stock (1985). Also orient yourself to the character of a good scientist. You should read *On Being a Scientist* (Committee on Science, Engineering, and Public Policy, 1995) and be reminded of your responsibilities to science and to the public. If you have had problems with writing or speaking in front of a group, spend a few hours reading about communication. The time spent may save you valuable time later when you are ready to report results of your research to the scientific community. Some books aimed at scientific communication that do more than merely serve as handbooks for acceptable usage in grammar, spelling, and punctuation and make good suggestions for improving your writing include Peat et al. (2002), Hofmann (2010), McMillan (2001), and Silyn-Roberts (2000) as well as Zinsser (1998). Zinsser is not a scientist, but he is an outstanding writer, and his comments on simplicity and clutter are in themselves examples of good writing for anyone. Paradis and Zimmerman (2002) can be valuable at both the advanced undergraduate and the graduate levels. For undergraduates, I especially recommend Gilpin and Patchet-Golubey (2000) or Knisely (2002), and both undergraduates and beginning master's candidates can find Goldbort (2006) helpful, especially Chapter 4.

As you get ready to publish and to go to meetings, read Booth (1998) for practical instructions about both writing and speaking. From their expertise as writers and editors, Day and Gastel (2006) offer a cookbook of brief directives on writing journal manuscripts for research publication. Gustavii (2008) also gives good suggestions for writing a journal manuscript and especially on illustrations. Anholt (2006) is good on presentations. Briscoe (1996) provides good information on poster presentations. If you need a guide to sources of information in a specific biological discipline, take a look at the guide by Schmidt et al. (2002). Some of these books focus primarily on a particular discipline, but most have good suggestions for all of the sciences. For example, Gustavii (2008) and Peat et al. (2002) aim their work toward the medical sciences, Knisely (2002) and McMillan (2001) at biology, Van Aken and Hosford

(2008) at the physical sciences, and Paradis and Zimmerman (2002) at both science and engineering; however, all of these have value for any of the sciences. I especially like Gustavii's direct, concise chapters titled "Basic Rules for Writing" and "Comments on Scientific Language."

You will not want to use them for bedtime reading, but you should be familiar with other good reference books. Your word processing program will probably have a spell-check, a grammar-check, and a thesaurus. Use them, but they will not always answer your questions. Have readily available an unabridged dictionary and perhaps a thesaurus and also a style manual for your science discipline. Also, you do need a handbook to check grammar, punctuation, and language usage. The composition handbook you used as a freshman may be good, or check Tichy and Fourdrinier (1988). They are thorough with organization, development, grammar, literary style, and diction. For less laborious reading, get *Write Right* by Venolia (2001). She covers the essentials of grammar and punctuation, and the interspersed examples and quotes are not at all dull. It is probably the best choice if you do not already have a good handbook handy.

In addition, you will find that a book on technical writing can be helpful for many of your professional communications, especially short communications such as memos, short reports, letters, and resumes, which I hardly mention in this text. *The MIT Guide to Science and Engineering Communication* by Paradis and Zimmerman (2002) is good, and I like the one by Burnett (1994) called *Technical Communication*. Drawings and other illustrations are often crucial to scientific communication. Probably the most comprehensive source for information on science illustration is Hodges et al. (2003). You can also consult Briscoe (1996), the Council of Biology Editors (1988), or Gustavii (2008). These books can answer many of your questions on drawings, graphs, and other illustrations. Learn about the technical style manuals or style sheets that you need to use for your discipline—for example, *Scientific Style and Format* (Council of Science Editors, 2006), *AMA Manual of Style* (Iverson et al., 2007), and *The ACS Style Guide* (Coghill and Garson, 2006). Your discipline will have such a guide or refer you to one or another of these.

Scientific Style and Format, The Council of Science Editors (2006) has information on the basic style of most areas of science and contains a list of style manuals specific to each science. Be familiar with the style manual that deals with your area of study. It will answer almost any question you have about style and publication. Some of these guides go beyond the details of technical style to issues related to writing and publishing, such as copyright, peer reviewing, grammar and punctuation, ethical guides, and other kinds of communications such as the oral presentation. Before and again after looking at those books, study the text and the data presentation in tables and figures in two or three journals published in your discipline. Not all of these are done well, but you can observe what is acceptable for publication in your journal. Those journal articles can also give you a view of their scientific and technical style. You may need

to communicate with specific publishers for style sheets peculiar to their publications. Government documents, for example, have unique requirements. If you plan to publish in a journal, check the format and style of the publisher before you begin to write, and have handy any instructions from your publisher and a copy or two of the journal to which you are submitting a manuscript. Often, it is easier to see how an element of style is handled in the periodical or book than to find a rule for it.

2.3 OF PENCILS, MICE, AND CYBERSPACE

In addition to keeping up to date with sources of information, you need to keep current with changes in the language as well as the techniques and electronic equipment available for retrieving information, composing your own paper or presentation, and disseminating your message to others. Language is your primary tool in communication, but other equipment helps you to transfer language from your mind to the minds in your audience.

English teachers have always had a problem with change. It is almost impossible to keep up with what is considered growth and development of language by some or desecration of the mother tongue by others. Whether we like it or not, language is going to change from generation to generation, and as use of a term or construction becomes prevalent, little is gained by objecting to its acceptance. Be alert to all that is new, but I encourage you to err on the conservative side. As Alexander Pope recommended, "Be not the first by whom the new are try'd,/Nor yet the last to lay the old aside."

Particularly important is knowledge about electronic communication and other technologies that can serve your papers and presentations. The computer age has brought with it new vocabulary and new uses for old words. There are bits and bytes and DVDs and icons. Acronyms become words; permuted words become words. Nouns become verbs or verbs become nouns. "Input" used to be just a noun; it's a verb now, whether or not your dictionary says so. "Text" used to be considered only a noun. Now it is also used as a verb. "Fax" is not even listed as a verb in older dictionaries, but today it is a noun as well as a verb like "text" with a complete conjugation. "Online" is an adjective or adverb that describes a condition of a document or a human being; "I'm online now" is perhaps more common than "I'm here." It is the English teacher's nightmare. Nonetheless, the computer has given us advancement in communication perhaps almost as great as the invention of the printing press gave to the sixteenth century.

The effects of technology on professional communication are evident. We can send and receive information at a phenomenal rate. Scientists are just a phone or a computer away from being able to share data immediately. Literature searches are no longer limited by the time one has to plow through hard copy indexes or by the holdings of one library. The revising and editing of manuscripts no longer require scissors and paste. All of these developments can have a truly positive impact on communication, but we have to look at

FIGURE 2.1 Not all the hardware and software in the world will write the paper for you.

problems that can result along with the progress. You might want to read *Why Things Bite Back* by Edward Tenner (1996), at least the chapter on computers.

We need to keep a realistic perspective relative to appropriate tools. All the hardware and software in the world will not produce quality research, write the paper for you, or make the successful presentation to an audience (Figure 2.1). We must have a human mind, a human hand, and sometimes a human face with tools. Look at it from the same perspective our forebears must have had when the free-flowing pen and the pencil replaced the quill. Scribes must have been amazed at what the printing press could do for their work in the late fifteenth century. For them, moveable type would have been ingenious, and photocopy would have been a miracle. Despite our advances in communication, none of these tools alone will initiate the communication nor give to it an accurate interpretation. Do not lose sight of the importance of input and reception by human beings.

Take advantage of available technology, and if you are weak in computer literacy, take advantage of classes, workshops, or mentors who can help. As a scientist, you will be handicapped without access to the Internet, e-mail, and a fax machine. Learn to compose at the computer. It erases easily and does not leave smudges. Learn to revise and edit from the monitor. With data being easier to acquire and analyze, the dangers increase for trying to present too much in a small space or a short time, of being too wordy, or of putting too much information on a single visual aid. Make hard copy to proofread after you have proofread from the screen. Use the grammar- and spell-checks, but recognize their limitations. The spell-check will not put the *y* on *the* to make *they*, nor will it retrieve a word that has been omitted. You may have the problem of the young scientist who presented his research in the poster format at a national meeting. He meant for his objective to begin with "To assess …" but it actually began with "To asses …." He had spell-checked his text; the

audience at his poster smiled and were distracted from his scientific message. One person suggested changing the spelling of *to* to *two*. Certainly, viewers were distracted from the quality and seriousness of his research.

In addition to composing your manuscript via word processing, publishing from computer discs or simply sending electronic copy through cyberspace has several advantages. Traditionally, hard copy submitted to a publisher had to be reset into type for publication. This process provided opportunity for more errors than are made if material is published without resetting. But electronic publishing is not without errors; both the author and the publisher should coordinate their efforts and take care in the transfer and publishing of information.

For your own use, desktop publishing equipment and software programs can produce text of high quality. Digital cameras, film recorders, and scanners can be connected with computer units to produce slides or prints and posters. Letter-quality and laser printers produce copy that is ideal for posters or slide copy, and many printers now accommodate a large paper size that will produce an entire poster on one sheet. With interactive media, you can produce presentations that combine visuals, words, voices, and video action. Find what will work best for your communication effort.

Be alert for possible problems. Backup your input regularly on additional discs and hard drives. Keep hard copy and do not throw away your pencil. Paper and pencil are not nearly so prone to technical disaster such as losses due to electrical surges or illnesses from viral infections. No equipment is without fault. When you attach people to imperfect equipment, problems can arise. The power of information exchange can be used in unethical ways. Copying software and invading privacy through stolen access codes certainly have occurred. Question the credibility of everything you read, whether it is in hard copy or on a computer screen. Misinformation, faulty information, or misuse of information are dangers in electronic communication just as they are in books and other hard copy. Several sources are available with suggestions for evaluating material you find. Read about evaluating sources in Chapter 4, or check "evaluating sources" online.

With all the advancements in technology, the tools for communication are decidedly improved, but the basic principles remain the same as they were when the scribe carefully copied the wisdom of Pythagoras with a quill to preserve and communicate it for new generations. Make full use of the keyboard, the mouse, and networks, but do not simply default to what a program wants to do. Good software will allow you to make decisions yourself. Do so, and do not lose sight of what the Chinese and Greeks already knew when history was a child: Simplicity and clarity are essential in conveying a message.

Most important of all, do not let the technology dictate to you what constitutes good communication. We should not accept graphs that are too complex simply because the computer has the capability of producing them. If your default method puts graphs on a grid of vertical and horizontal lines, be sure to check to determine if your journal publishes such grids. We should not

accept distortions simply because your computer program will not produce the expected dimensions or form. The technology should in no way dilute clarity. Study the techniques for clear communication, and then make the equipment work for you. In this text, I deal with age-old principles of communication and hope that you can apply them to our changing world.

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Chapter 3

Organizing and Writing a Rough Draft

Brilliance has an obligation not only to create but also to communicate.

—J. R. Platt

You can do a variety of things before you actually begin to organize and write a paper or put together a speech or a poster. A common choice is to procrastinate. You can even rationalize that the procrastination is leading to better communication. The paper is due soon and so you take a nap to get a fresh start on it. Maybe you will watch a television program with a friend just to relax so that you will do a better job on the paper. You are even willing to wash windows or do laundry to distract yourself and thereby clear your mind for the important paper. The computer is right there, and so you play a computer game; you deserve the little break before the large task in front of you is begun. Be creative; you can surely think of many other diversions and rationalize your way into an artistic, well-crafted procrastination. But at some point, you'll have to give in to the need to produce the paper. For the good student or scientist, self-discipline will win despite the numerous skirmishes that procrastination wages in opposition.

Once that battle is won, consider what you may need for the paper or speech. Think about it. Determine what kind of paper you are to produce, isolate your purpose, and reflect on your subject and your audience. Then you need to set your mind on the paper itself, its content and organization, and perhaps go through a few prewriting exercises to condition yourself for producing a rough draft.

3.1 THINKING AND WRITING

You can think well; you can write well. I am convinced that clear writing depends on clear thinking. And, like Zinsser (1993), I believe writing helps you to think and to learn. However, do not let your thinking get too far ahead of the writing. Thinking alone allows you to skip around, to move at random through a batch of ideas. The physical symbols (words) you put on paper help to direct your thinking and to make you recognize any gaps in logic and to focus more

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clearly on your purpose. Some people can visualize physical situations, can organize plans in their minds, and can work out mental details for such projects as building a barn or repairing a motor. More often, the carpenter will sketch or look at a sketch of the barn, list materials and numbers of board feet needed, and stand on the building site to visualize the structure. The mechanic will almost always want to look at and listen to the motor. The tangible substances help these professionals coordinate their ideas and skills to produce results.

Words on paper have a similar symbolic influence on thinking, learning, and writing. The physical words keep ideas in perspective and contribute to logical, orderly arrangements of thoughts. However, some people avoid this learning device because they find that moving thoughts to paper is difficult. Some find the writing itself relatively easy, but getting started is difficult. Multiple influences go into writing a scientific paper—the research, the data analysis, what others have written, your colleagues' opinions, your audience, your ability with words, the time you have for writing, how tired you are, what other thoughts are in your mind; the list becomes endless. Juggling your thoughts and having them all fall into place neatly on a page are difficult, but what cannot be done in the initial writing can be done through revision. You must create a rough draft before you can revise.

Students often tell me that getting started is the difficult part. Some outline; some do not. Some wait for time to pressure them; some write better without the pressure. Write the way you do it best. But if you are having trouble deciding what is best for you, try a new approach by choosing one or two of the following ideas.

3.2 PREWRITING EXERCISES

3.2.1 Think Before You Write

Your first efforts should be to think about the audience, the subject, the purpose, and yourself. Go through a series of questions and see that you are satisfied with your answers. What form will the writing take? How do I talk to this audience? What are they asking? What are my motivations? Do I believe in what I am saying? Do I have the materials I need, including the literature, the data, the understanding, and the references? Jot down brief answers or notations to these questions. Do not linger too long, but think long enough so that you do not resort to the excuse of not being ready to write. When you have all the auxiliary matters out of the way, your thinking is clear, and a few notes are written down, then go to another prewriting exercise or start writing the draft.

3.2.2 Talk Before You Write

Prime yourself by trying to tell the material to a colleague, a spouse, a friend, or your pet. You can even talk to yourself via an audio recorder. The recorder

will hold your thoughts until you need them again. Talking out loud, like reading aloud, can cause you to recognize logical progression of ideas or what is missing from your information. Involving your own ears and those of someone else can help you hear what details need to be included or emphasized and the order needed for clarity. Request that your listener make comments and ask questions that will show you points that may be clear to you but not to someone else. With or without input from your listener, write immediately after talking while the subject is still up front in your mind.

3.2.3 Brainstorm, Freewrite, or Make a List on Paper

Just start putting appropriate words on paper. This process can consist of a concept map of ideas in boxes or circles joined by arrows, or it can be a running text of sentences as they come to mind. You may want to list the questions you think the audience will want answered and make notes on answers you will give. Try old-fashioned note cards; they are easy to shuffle and organize. You may wish to use the computer for this initial brainstorming, but I like the pencil and the freehand ability to quickly draw lines or arrows between words and put ideas in boxes on paper. Once you have a physical list of ideas in one form or another, you will be better able to organize the material. Do not spend a lot of time trying to perfect this list; get to the real draft soon. The point in any kind of brainstorm writing is to get ideas down on paper. You may throw them all away when you really get organized, but they are the stimulus and the material for your organization.

3.2.4 Outline

You may begin by outlining, or the outline may follow the brainstorming, freewriting, or talking. Some people can use either a rough outline or a perfected one to organize before they write any full sentences. Others may use outlining as an intermediate step to revise a first draft. Write first and then outline to perfect organization and development and then rewrite if that technique works best for you. Once you have produced the outline, do not let it take control. It needs to be flexible so you can reorganize if need be. The outline should include the main sections and the secondary points of the paper. For a journal manuscript, you might simply list Introduction, Methods, Results, Discussion, and Conclusion and then list major points under each section and the important subpoints under those.

3.2.5 Write a Rough Abstract First

An abstract can be a kind of outlining. The scientific abstract for a journal article generally requires you write a sentence of rationale, a statement of objectives, a notation about methods used, a list of most important results, and any

conclusion reached. A draft of an abstract will set forth the main points about which the paper must elaborate. Consequently, it can get you started in an organized manner. And, like the outline, it guides you through the entire paper in that you simply add details and expand upon each part of the abstract.

3.2.6 Start in the Middle

Some people have trouble introducing a subject but know what they will say in the main body of a research manuscript. Above all, first write down your objectives. After objectives are very clear in your mind, you may find it easiest to write a full draft of the methods and then, based on these methods, you can write what resulted. You might even write a draft of the conclusions first to focus on the main point you want to leave with your reader. An introduction could be the first or the last part written. Do not waste time by trying to produce a perfect paper from beginning to end at the first sitting. Start in the middle and fill in around the edges as you can. The need for revision is a fact of successful writing. The important thing initially is to get something down on paper to revise.

3.2.7 Get Rid of Your Inhibitions

Loosen up. Most of us have inhibitions about writing the same as we do about speaking to an audience. Those inhibitions often have come from the same people who intended to teach you to write. Even on papers you wrote for composition class, busy teachers may have commented little on the content and too much on the small errors. Maybe they scrawled an "excellent" or a "good" at the top of your paper. I was also familiar with "very poor." Too many "excellent" comments on your papers in high school or college freshman English class may have been detrimental to your writing in that you came to believe your first drafts do not need revision. I have never seen a first draft of a scientific paper that needed no revision. Also, despite having little to say about your ideas or content, those same teachers' red pens bled freely across the mechanical errors in grammar, punctuation, and spelling. And they may have preached the gospel of the Rules. We often reach graduate school still cowering before the mighty Rules. And, alas! The rules are flexible. Although I respect conventional standards for good writing and rely on grammar handbooks to show me what is conventional, I do not believe in allowing rules to distract from the content in a first draft. Write your first draft without worrying about mechanics. Then be sure you use the conventional forms when you produce your final copy.

I suggest you keep a handbook of grammar and punctuation handy and use it as you work with your revisions. If you have a great deal of trouble with the mechanics and effective writing in English, spend some time reviewing these things. Some good discussion, lists of conventions, and examples can be found in numerous books, including Hofmann (2010), Venolia (2001), and Peat et al. (2002). My first recommendation is Venolia. She is concise and has excellent

BOX 3.1 Ransom's Rules for Technical and Scientific Writing

1. If it can be interpreted in more than one way, it is wrong.
2. Know your audience; know your subject; know your purpose.
3. If you cannot think of a reason to put a comma in, leave it out.
4. Keep your writing clear, concise, and correct.
5. If it works, do it.

examples. Hofmann has a great deal of discussion with examples as well as exercises you can do with grammar and sentence construction. If your problems are minor, the best set of rules I have seen proposed for scientific writing was suggested to me by Nora Ransom at Kansas State University (Box 3.1). My own comments on major weaknesses in scientific writing are in Appendix 1, but the following are the only rules you will find in this book.

Whatever technique you use to get started, get started. Do not spend too much time on these prewriting exercises. Write. Do not let any of the monsters on the fringes of your thoughts deter you. Thoughts of an unreceptive audience, thoughts of other things you could be doing besides writing, hang-ups on the rules or mechanics of good usage that your English teacher has instilled in you—all such devils should be driven from your path. The only way to get something written is to write. Do it your way. In your revisions, you can spend time thinking of the audience and being sure your paper or presentation is well organized and that all the language monsters have been subdued so that you are communicating well. Notice the very rough draft of a simple essay in Appendix 2. It will require extensive revision before it is an acceptable draft, but it was written in 10 minutes and it gives the writer a foundation to revise for a good essay.

3.3 ORGANIZATION AND DEVELOPMENT

During the thinking and prewriting processes, you may organize your material within a format. Further organization may, however, be a chore that follows after prewriting exercises or after a freely written rough draft. Once the draft is written for the entire paper or for a section, get more specific with organization. Organization produces a unified package that makes both sending and receiving information easier. In addition to arrangement of content, you use language tools—words, sentences, and paragraphs as well as symbolic signposts such as transitions or headings and subheadings—to direct the reader or listener through the organization and development of your content.

Organization and development are concepts that cannot be separated. It may be that a second point in your organization will not be understood until the first point is developed. To keep the progression of ideas orderly, keep the audience in mind at all times. Think of someone listening or watching

you write who is asking questions repeatedly: “What did you do?” “How did you do it?” “What do you mean?” “What caused that?” “Can you give me an example?” Answers to such questions constitute development of ideas, of sentences, and of paragraphs. This inquisitive little voice over your shoulder can help you keep things in order and tell you how much development you need. It will remind you when you are using too much jargon or need to explain further or when you are proceeding too fast without making clear the background, definitions, causes, and effects.

In writing or reading a paper, we progress from word to word, from sentence to sentence, and so on, building larger and larger units of material until the full paper is written or read. In organizing a paper, we use the reverse procedure. We first consider the largest units. To an extent, the kind of scientific paper will dictate the largest units. A journal manuscript, for example, will almost invariably follow the IMRAD (Introduction, Methods, Results, and Discussion) format. Other papers will require different main sections. For example, proposals may have a framework of Introduction, Justification, Background or Literature Review, Methods, and Conclusions. A thesis may require yet another primary organization, as will a review article. The large sections of your paper may be more lucid if based on chronological order or a step-by-step process; they may be based on spatial arrangements or geographical order; or they may be divided by meanings (two or three related experiments, comparisons or contrasts, causes and effects, pros and cons).

When the framework is in place, we must consider each smaller and smaller organizational unit. For example, a Methods section may be divided into subsections on Materials, Steps in Experimentation, Data Collection, and Scientific and Statistical Analysis of Data. Under each of these subsections may be tertiary sections describing treatment 1 and treatment 2 or location 1 and location 2, with smaller divisions under each of these.

With primary details clear in your mind, you can quit organizing and start writing. When you begin to write depends on your personality, your expertise, and the way your unique brain works. Some people start writing as soon as main headings are established; some need details down to the developmental topic for each paragraph and even subtopics within the paragraph. It all sounds very simple, but the important point is to be sure that you extend your organizing to the smallest unit you need before you attempt to move in the other direction and write the paper. Notice again that, as you **organize**, you proceed from the large to the small:

Sections
Subsections—Subsections
Sub-subsection—Sub-subsection—Sub-subsection
Paragraphs—Paragraphs—Paragraphs—Paragraphs
Sentences—Sentences—Sentences—Sentences—Sentences
Words—Words—Words—Words—Words—Words—Words—Words

And when you **write**, you go from the smallest to the largest unit:

Words—Words—Words—Words—Words—Words—Words—Words
Sentences—Sentences—Sentences—Sentences—Sentences
Paragraphs—Paragraphs—Paragraphs—Paragraphs
Sub-subsection—Sub-subsection—Sub-subsection
Subsections—Subsections
Sections

Main sections may be labeled with primary headings, subsections with secondary heads, and sub-subsections with tertiary heads. You will probably not need more specific labeling. Paragraphs indicate new development of an idea just as capitals and periods tell us where sentences begin and end. Unless a publisher or other authority dictates differently, I still believe in indenting paragraphs; the indention is just another transition or visual clue to the audience that you are shifting to a new point for development.

Outlining in your mind and on paper can be the most efficient way of saving yourself time and staying on track. You have likely developed your own methods for outlining or organizing. If not, try the following. First, simply write down the major headings—for example, Introduction, Methods, Results, Justification, and so forth—and then start making notes or lists under each heading. You may immediately see an outline emerging. You may, however, need to arrange your list further by subordinating some ideas to others, putting materials into categories, and giving an order to what needs to be told first, second, third, etc. Now an outline is emerging. If you are a tidy person, you may want a formal outline. Montgomery (2003) has suggestions for organization. An English handbook can provide guidelines for outlining, or read Chapters 3 and 4 in Tichy and Fourdrinier (1988) on concepts of outlining. See the generic outline in Appendix 1 and the example of a simple outline in Appendix 3.

3.4 COORDINATING ORGANIZATION AND DEVELOPMENT

If you can get basic organization as well as content development into an early draft of your paper, your work with revision will come much easier. Note how organization and development work together for the rough draft in Appendix 2. This simple essay is a rough draft that could easily have been written by a high school student, but notice the potential for developing such a draft into a bona fide paper. The elements of organization include main points and transitions that carry the reader from one point to another. Now look at the outline in Appendix 3. It is still a very simple paper but illustrates what you need to do with a more complex one. The outline guides the writing from point to point as it follows the typical IMRAD formula, the most common external organization for a scientific report.

3.4.1 The Point of Emphasis

Organization may appear disjointed or fall apart unless it is tied together with a thesis and transitions. In this instance, *thesis* means the theme, the motif, the focus, the overriding point around which everything in your paper should revolve. For communication, art and science follow the same principle. A good musical composition or piece of literature carries an overriding motif and lets us hear it or consider it from several vantage points. The question that the scientific audience asks you is “So, what’s your point?” Over and over you need to reiterate that point or thesis.

If we employ physical imagery to interpret this concept, we can think in terms of the blocks of information that make up the various sections of a research report. A common thread must be woven through these blocks to hold them together. Most scientific papers emphasize one main point and maybe two or three subpoints. The hypothesis is one version of this main point and the objectives are another. Methods provide another view, and results concentrate on what you found out about that point. Any discussion and conclusions must strictly adhere to the point. With concentrated focus on your thesis, the organization is not likely to stray.

I like to think of a well-organized presentation of a clear thesis, or a focal point, like a common thread moving in a spiral or circular pattern rather than progressively or linearly from a first to a last. The first and main point, usually the objective, weaves in and out throughout the paper and comes to rest as another view of the same point in the conclusion. If you proposed a possible hypothesis or answer to a question in the introduction, you weave in and out through the paper and often loop back to that question and then finally conclude with an agreement or disagreement to your hypothesis in your conclusion.

3.4.2 Transitions

When we talk about organization, we are talking about a road map that will carry you and your audience through the various developmental blocks or units of materials that make up your paper. In addition to a thesis or main point of emphasis, we need mortar or bridges to join the blocks, and we need signposts to direct the reader along the road. If you think of the thesis as a thread, these connections are loops in the thread that sew one section or idea to the next. Those language devices that hold your paper together are transitions. They help to unify and move the point of emphasis through a series of ideas to a conclusion. Notice the examples of transitions in Appendix 2.

Transitions serve both to join parts of a subject together and to convey meaning. Like the Roman god Janus, transitions look in both directions at the same time. They remind you of what was just said and signal movement to the next idea in your paper. They may be conjunctions or prepositions that hold parts of a sentence together with distinctive meanings. For example, the short

words *and* and *but* are transitions that carry opposite meanings. The same is true of *to* and *from*. Keep in mind the functions of transition as joining two parts together and carrying the message forward with meaning.

Beyond simple words as transitions, you can use phrases such as “on the other hand” or “in the same way.” You can use full sentences: “To reduce the bacterial populations, we used chlorine in the first experiment. In the second, we substituted fluorine.” The full sentences are transitional, and they contain the transitional words *first* and *second*. You can also use full paragraphs as transitions between two more complex points. Within those paragraphs, you will likely find several smaller transitional elements.

Another transitional device is repetition. You can repeat the same word or phrase, or you can repeat the same idea in different words. This kind of transition is important for carrying a major point or motif throughout a paper, referring to it again and again to keep the reader focused on that point. But, use transitions discriminately. Readers may become insulted if the text becomes wordy and repetitious. Do not become redundant. However, in a variety of ways, keep reminding the reader of the main point. Some repetition in styles used for headings, in sentence structure, in symbols, or in colors and designs can serve as unifying elements and as transitions. Good transitions make a paper or a speech flow smoothly and keep the communication from being jerky or jumping from one point to the next. For a more detailed but brief discussion on transitional devices, consult Marshek (1982).

Whatever connections you use or however you visualize your unified paper, the overriding requirement for good organization is clear, logical thinking with use of accepted conventions and order. In other words, if you do what is expected in a reasonable manner, your writing will be most clearly understood by other reasonable people who use your language with the same conventions. Whether it is a misspelled word, an awkward transition, or chaotic organization, misuse of the language will distract from communication. (For those of you whose first language is not English, you may want to read Chapter 20 and, for writing in English, work out any differences in organization that your culture has instilled in you.)

3.5 WRITING THE ROUGH DRAFT

Once you have corralled your thoughts, with or without prewriting exercises, and considered your organization, you are ready to write a rough draft of a short paper or a section of a longer work. At this point, I assume that you have focused on one point of emphasis and listed supporting secondary points. You have thought through what you want the audience to know when you have finished, and you have considered what their questions are. You have gone through some prewriting exercises and have produced an outline or other organized pattern for your work or have made a list and then organized your ideas so your audience moves with you from one point to another. With all this

preliminary work done, begin to write immediately. Any delay at this point is distracting.

In this first draft, forget perfection, forget grammar and mechanics, forget editing. Just write quickly and get a draft composed that you can edit. Keep in mind your first production is a rough draft and will require revision. Perhaps a first draft such as Moses' Ten Commandments could be set in stone; yours should not be. Your words are not sacred. When you have written a rough draft, be willing to tear your words apart, throw some away, insert new ones, and rearrange them until they say what you want them to say. This revision is the way a good paper is produced. But you have to have a rough draft to revise.

Language is really not so haphazard as it sometimes appears. Lack of clarity results only when a speaker or listener (writer or reader) deviates from logical organization, from standard meanings of words, or from expected form or word order. Think clearly before you speak or write, and the audience should receive your message without misunderstanding.

Even after careful organization, some people have problems getting started. There are not hundreds of ways to approach writing. Do not waste time wondering how to start. In creative writing, approaches such as stream-of-consciousness or story telling can add artistic or philosophic dimension to writing, but for scientific writing, you will seldom need to know how to handle more than the following four approaches: **define**, **compare–contrast**, **enumerate**, and **give cause–effect**. Choose one of the four and start to write immediately. Do not ponder. Do not use up time at this point. Pick one (or two). The others are all in the back of your mind and can be summoned at a moment's notice. Notice the use of these approaches in Appendix 2.

Compare–contrast
Enumeration
Definition
Cause–effect

Numerous key words used in asking and answering the audience's questions will control the development in your paper or presentation. You may develop ideas with evidence, example, detail, points, methods, classification, results, summary, reasons, alternatives, and possibility. All these words are related to the four approaches. For example, evidence may be cause and effect or a definition or an enumeration of points or a comparison or contrast. The questions from the audience may take many forms, but the techniques involved in the reply are limited. Your answer will characteristically begin with a general assertion followed by details to explain and clarify that assertion.

The audience and their questions will often tell you how to start or, at least, hint at an approach: "What is a quark?" (definition) "What caused that result?" (cause–effect). If you must choose the approach, as in Question 4 that follows, you usually know which one you can handle best or which will best serve the audience.

3.6 EXAMPLES

1. Question: What are your methods for __________?
   Answer: Enumerate 1, 2, 3, 4 methods; then define, probably by enumerating steps in a process, showing cause and effect, or comparing and contrasting.
2. Question: What are the differences in __________ and __________?
   Answer: Define terms and then contrast differences probably through enumeration.
3. Question: What is __________ and how does it affect __________?
   Answer: Definition and cause–effect.
4. Question: Why use continuous rather than intermittent flooding in rice?
   Answer: Here, none of the four approaches is obvious, but you choose one or two and begin immediately. Probably you need to enumerate cause and effect: (1. weed control; 2. less loss of nitrogen; 3. greater yields) and compare–contrast to intermittent flooding (enumerate again).

A common way to begin an essay or a paper is with definition. A formal way is to begin by putting that term into a general classification of related ideas and then point out its distinctive qualities.

Formula: __(term)__ is __(class)__ which __(distinction)__

__(term)__ __(class)__
Example: Factorial ANOVA is an analytical technique in
__(distinctions)__
which two or more variables and their interrelationships can be identified… (Continue to enumerate other distinguishing characteristics.)

Comparison and contrast or cause and effect almost always involve definition and enumeration. Both approaches lead to examples and **tangible details**. A person can get lost in technical terms if tangible images are not occasionally formed in the mind. A tangible image is one that relies on the senses (or a past sensory experience) for understanding. We see, taste, smell, hear, and touch tangible examples. Words such as *understanding* and *concept* are not tangible, but others such as *lemon*, *freight train*, *square*, or *rose* throw images into our consciousness to increase our understanding of an idea or concept. As you experience scientific and intellectual concepts, your senses are still at work. Terms such as *hydrogen sulfide* or *staphylococcus* are understood in part through your senses of smell or sight once you have encountered the real substance. Notice the difference as we add tangible details in the following:

General Factorial ANOVA compared relationships of two or more factors.

More specific Factorial ANOVA was used to determine interrelationships of two treatments on three soybean cultivars at two locations.

Most specific Factorial ANOVA was used to determine interrelationships between foliar applications of nitrogen and boron on “Forrest,” “Davis,” and “Clark” soybeans in field plots at Fayetteville and Marianna.

BOX 3.2 Checklist on How to Organize and Write a Rough Draft

1. Determine what questions your audience may ask.
2. List ideas that will convey the answers.
3. Arrange the ideas in an orderly sequence.
4. Using your own judgment, choose one of the four approaches (define, compare–contrast, enumerate, give cause and effect) and write immediately.
5. Recognize the need to revise.

Communicate with the senses. As your communication becomes more specific, you alert minds in the audience to specific images that define and explain your message. If you are communicating with an audience that would not understand your tangible image, you should define. No matter how theoretical your scientific communication must be, keep as close as possible to the tangible details your audience will understand. If the senses cannot be involved to make the details tangible, at least be as specific and as simple as possible with intellectual concepts.

A great deal of time is wasted in struggling with a first rough draft, and focusing your own mind on the tangible details can help. Do not worry with perfection at this point; you simply need a draft to revise. If necessary, set a time limit, ask yourself the appropriate questions, and then write detailed answers with as much organization as possible. Although Appendix 2 is hardly scientific, notice how it roughly displays organization, development, transitions, and the four approaches to writing.

As you gain experience in writing, you will use the basic approaches to organization and development of ideas without realizing that you are doing so, just as you use periods at the ends of sentences and start the next with a capital without having to remind yourself each time. But when you are having trouble getting started or are revising a paper, it is good to think about the possibilities (Box 3.2).

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Chapter 4

Searching and Reviewing Scientific Literature

Do not condemn the opinion of another because it differs from your own. You both may be wrong.

—Dandemis

If I have seen further … it is by standing on the shoulders of giants.

—Sir Isaac Newton

4.1 PLANNING THE LITERATURE SEARCH

Any scientist needs to be familiar with the work that has been done in his or her area of research and with what others are doing concurrently. No scientist, however, can read all the books, articles, and other printed matter related to a given area and perhaps not even all that is concerned with a special topic. Therefore, we need to be selective and to find the most pertinent literature on a subject as efficiently as possible and to use it effectively.

Literature reviews are conducted to supply backgrounds or to be integrated into research projects, proposals, journal manuscripts, and other reports. For a graduate student, a review of the literature may constitute an entire chapter of one's thesis; it certainly will help the student to understand the objectives of his or her research. Similarly, scientists at work on research objectives need to know what has already been done or need to investigate the most current methods for pursuing an experiment. Reviews can also be published as journal articles or chapters in books, and these can be informative introductions and discussions of research discoveries that have been made.

The technology gods have made searching the literature and compiling and maintaining a bibliography easy compared with the tedious processes of a few years ago. However, I recommend caution in depending on the Internet to do your entire search. It is still seriously flawed for a complete, adequate search on any given subject. That is not to say it is not helpful. Before you sit down at a computer and expect the Internet to send you the needed literature at the touch of your fingers, consider how best to approach this task.

A deliberate, well-organized approach to a literature search can save you a great deal of time and energy. Searching the literature is a continual process,

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but first you will need to explore ideas related to your subject, conduct a specific search in relation to your research objectives, and certainly keep current with what is published while you are pursuing your objectives or writing the paper.

An **exploratory search** can be conducted before a clear hypothesis and clear objectives have been established. During this exploration, you will investigate the full scope of the subject area and determine topics of special interest to you and what has already been done on them. Then, look for gaps in the research and decide what specific experimentation to propose and pursue. Certainly, much of this exploration can be done online, or a published review in a book or journal can be helpful. In exploring the literature and in the more specific search that follows, you need to look for any duplication of your efforts. If someone has already done work similar to what you propose to do, you may need to alter your plans to avoid reinventing the wheel.

The **specific search** is essential for providing background to your own work and for revealing where and how your research fits into the scientific pool of information available. It will begin with a survey of information associated with your specific goals or objectives. This search can be triggered by a single publication on a subject that gives you a list of references to check. As your research progresses, you will encounter even more specific needs. For example, you may be using a method and need to know how others have used that method and how much success they had with it or what new equipment is available to employ with your procedures. In such situations, your specific search becomes limited to answering the questions you have in mind.

When you are writing your review and then doing your research, keep current with ongoing publication. The **current search** can be continually maintained through computer updates, habitual reading, interaction with your professional peers, and periodically checking current awareness sources that can e-mail to you titles or full articles just being published. Certainly, the Internet is valuable for keeping current.

In designing an overall plan for a search, consider the following principles.

4.1.1 Visit the Library

This admonition may sound facetious, but I am quite serious. Your personal computer may be connected to a network whereby you can do some of your searching through your own office or home computer, but you will do well to visit a library at a university or other educational or research institution. Browse for 30 minutes or more, and check out the systems for finding and acquiring materials. Do not hesitate to ask librarians for information; take advantage of their expertise. Attend sessions they may offer on new tools for searching, retrieving, and compiling the literature and bibliographies. Collect any flyers or brochures with information about the library and how it serves you. Determine where special materials such as government documents are

filed and how to gain access to materials housed in other libraries. Interlibrary loans may be free, or a fee may be charged for acquisition of materials from other libraries. You may be able to go online to browse at other libraries, or if you need a specific book or article not available at your library, a staff member at an interlibrary loan desk may locate it and order it for you. A general familiarity with the library can be a real asset as you search the literature.

4.1.2 Allow Time

Often, scientists are so interested in what is going on with research or its application that they neglect the literature search. You can actually save time in some instances by consulting the literature to discover the latest data compiled on a subject or a new technique for accomplishing your goals. More important than saving time is your responsibility for knowing what has been and is being done in your area. This knowledge is essential to scientific communication whether you are writing a proposal for new research, reporting results of a study in a poster, making a slide presentation, or writing the journal manuscript about completed research. Give yourself time to explore, find, and read about your subject and perhaps time to write a review of the literature.

4.1.3 Isolate Your Objectives

You can waste time when you spend too much of it exploring before you establish a specific search or if you repeatedly get sidetracked on interesting subjects related but not directly associated with your goal. Consider the reasons for your search, how much time you can spend with it, and what you are trying to find. For a thesis, proposal, journal manuscript, and other reports, you are likely looking for support for your objectives or the answer to a question. Once you have declared a specific objective, stick to it in your search. At least be sure that any interesting sidelights are worthy of the time you give to them.

4.1.4 Document Carefully

Make detailed notes on important works you find. For a future bibliography, you may need authors' full names, full titles, journal titles, volume and page numbers, publishers, dates of publication, electronic access address, and any other information relevant to the style of the publisher to which you submit a manuscript. Ensure that any photocopies or computer-derived copies you collect have all this documentation on them. These copies can be a great convenience, but overuse of the practice can be detrimental to writing a review of the literature. Voluminous piles of copied materials can be just that—unorganized piles. Develop some system for filing photocopies so that important information does not get lost again after it has been found. Read or at least scan the material as you acquire it, and make notes on points that apply to your work.

A note attached to the paper is handy for highlighting information from the articles. Three weeks later and with numerous articles retrieved, you may not remember which one contained that important information. To make a bibliography, you may want to invest in a software program, such as EndNote, ProCite, or RefWorks, for compiling and filing your references. Your library may provide free access to one of these or some other software. Librarians or computer "Help" information can get you started using these programs.

4.1.5 Be Selective

Not everything written about your subject is relevant to your specific work. Some publications can be substandard, and reference to them can jeopardize your own credibility. Leaving out important works can be as bad as including questionable work. Discriminate relative to source, author, date, and relevance as well as the credibility of the research reported. Other discriminating scientists are familiar with the literature and with the scientists who are working in a given area. They are not impressed by work padded with irrelevant literature or with that which fails to give reference and credit to the pertinent studies. Be especially careful in selecting literature from the Internet. Your library has probably been somewhat discriminating in choosing books and journals that contain valid educational materials, and the databases they access via the Web are generally reliable, but ultimately the discrimination has to be entirely yours when you use the Internet. For further suggestions on credibility of sources, see Section 4.3.2 on evaluating sources.

4.1.6 Verify

The most important principle that you can follow in searching and using the literature is **accuracy**. Careless use of ideas that allow ambiguous interpretation can damage your reputation. Careless documentation that leads fellow scientists to waste time pursuing a faulty reference should lead to your obliteration from the scientific community. Whatever style you use, be sure to include not only accurate but also enough information for a reader to find the source to which you refer. To load your bibliography with what you think may be proper spellings of names or proper volume and page numbers is as dishonest as loading your scientific data. Verify all ideas and documentation.

4.1.7 Be Willing to Quit and Create Something Useful

Almost any library search can be extended indefinitely. Do not leave a search before a good job is done, but do not continue to follow blind leads that give you fragments of remotely related material. At some point, you must be willing to discontinue the search temporarily and apply what information you have gained to your research and to your writing. You can and should always go back for more and for an update.

From your notes and documentation, put together a draft of your bibliography. Sort out articles and books directly related to your own study and also write a rough draft of a review on the subject. This writing can be important to a proposal, a thesis, and a subsequent journal manuscript, speech, or presentation.

4.1.8 Verify Again and Keep Up-to-Date

Accuracy is so important that it needs to be considered repeatedly as you collect the literature and when you use it. Check your bibliography and literature review against the original sources. Be sure there are no errors. Verify every time you revise and especially before you submit a paper to reviewers and editors.

We are all familiar with the college professor who is still lecturing from notes he or she made as a graduate student. Do not fall into this trap. Many thousands of books and articles are published every year on scientific subjects. Some of those relate to your work. Find them.

4.2 FINDING THE LITERATURE

As with any job you do, in searching the literature, you need to be familiar with the tools, terminology, and sources of information. Research findings and other scientific information can be published in books, monographs, proceedings, journals, dissertations, patents, standards, governmental bulletins or reports, and a variety of other sources. Primary and secondary source materials are published in various formats: paper, electronic, microfiche, video- and audiotapes, and other media. With different searching techniques, access to these materials is available through indexes, databases, and catalogs. Finding one source may require an online computer search, and still another may come from a manual index or a conversation with another professional.

As with managing your citations and bibliographies with such programs as Endnotes or RefWorks, using online search engines can be beneficial to finding the literature you need for your research and communication. Through searches with such avenues as your professional society's website, SciFinder, Science Citation Index, CAB, Agricola, Medline, or others, you can access a great deal of literature. However, do not stop there. Searching through just one of those engines may give you only 30–50% of the literature on a particular topic. I asked our senior reference librarian, who has worked with online searches since they came into being, whether a search on a given topic with six different search engines would get me at least 90% of the sources on a subject, and she shook her head and said "no." For a thorough search of the literature, you will probably do both manual and electronic searches. Before you do either, think of what you need and how to get the most out of your time and effort.

First, talk with people. Do what you learned to do in kindergarten—share. Give and take information. Talk with fellow graduate students, your professors, your colleagues, or your coworkers. Talk with people at meetings, especially those presenting material related to your own. It is amazing how much you can learn at a professional meeting that is not posted or presented. Talk about your work and theirs and who else is working on similar topics and has published on those topics. Always carry a note pad and a pencil. Write down ideas and references. Collect references from posters and presentations. In other words, network. Then extend that network farther. Collect those publications you have heard about that appear most closely related to your own work. Look at the reference lists in them, collect the articles, and read them. In them, you will find other reference lists. Find those and read them. Check on their references. If you keep letting author after author lead you, you will soon have a sizeable list yourself. This technique is what Smith et al. (1980) call a "snowball." It keeps getting bigger and bigger. With this technique, you will probably spend less time searching than it would take with online searches to get the same number or perhaps fewer applicable references. Keep in mind that this technique takes you back in time and the references may become less relevant—or maybe not.

But do not stop. It is time now for online search engines. Use them and see what else they yield. Go to WorldCat, the largest index of published literature in the world. Academic libraries have access to WorldCat, but if you do not have access to a good library, you can go online and find it. You will probably need to register and pay a fee unless your library provides it free, but it may be well worth the money. Beyond the online search, to find less known or less recent materials, you may need to go to manual indexes at a library or to microfiche files, government documents, patents, or other sources that may or may not be online now. Keep in mind that many online search engines may not yet index materials prior to the 1960s or 1970s. And rest assured, there are some publications even earlier than those years that are valuable today. In addition to looking back to early publications, look forward to those being published but maybe not yet indexed. Current awareness sources such as Current Contents Search, Ingenta, and Articles First will give you relatively recent information. Also, keep current with your networking.

Various guides, such as Schmidt et al. (2002), can provide information on online searches as well as on indices, abstracting services, and other avenues for finding primary and secondary literature. List (1998) and Munger and Campbell (2006) may be helpful in showing you effective online search techniques. Others, including Knisely (2002), McMillan (2001), and Smith (1998), give some insights into searching and using scientific literature. Smith et al. (1980) provide basic information on manual searches. However, your best guide for any search is a reference librarian. Many libraries provide specialists in the various disciplines. They can identify for you what is available online

and elsewhere and can assist you in formulating strategies, choosing relevant key words, and using Boolean operators. Take advantage of the services they offer, including any classes or teaching sessions on library searches. For electronic access to information and literature retrieval, be sure to keep up with what is available. What I say here may be outdated next year. Always keep relevance and credibility in mind as you acquire information from any source.

4.3 SELECTING AND EVALUATING THE LITERATURE

4.3.1 Sources to Use

With the plethora of information available on any subject, it is vital that you select the sources relevant to your specific topic and reject the irrelevant or inappropriate. You will want to read completely all sources closely associated with your study. However, you will retrieve numerous references not so important to you, but you will not know that they are not important until you scrutinize them. Develop a method for saving time and finding out whether you should read the entire article. If the title appears pertinent, read the abstract, headings, and topic sentences or summaries. If those still indicate information that may be helpful to you, read the conclusions and look at relevant data in any tables and figures or at a method that may be pertinent to your research. By the time you have done all that, you should know whether to study the entire article. Using this technique to screen articles can save you some time, but when you decide to cite a reference, be certain that you have read all of it. You need to be thoroughly familiar with all that the authors are saying. Misquoting or taking a finding out of context can constitute an inexcusable inaccuracy.

Although it is often difficult to be selective, every reference you use should be credible and relevant to your own work. The literature may be relevant if it serves as a historical background to establish the position of your research in a larger framework or if it teaches you a new method or gives you new ideas to pursue in accomplishing your own objectives. It may illustrate or justify a specific point you make in your work, or it may support a result you find, a method you use, or a conclusion you reach. Include the citations that disagree with results from your own research. Determine why other researchers got different results, and report the differences. An unbiased, comprehensive discussion of the literature will increase your own credibility.

4.3.2 Evaluating Sources

After you have collected all the literature you can find relevant to your study, you need to determine whether each source is an appropriate, credible reference for your literature review. How appropriate it is will depend not only on the quality of the publication but also on how valuable the reference is relative

BOX 4.1 Judging Relevance and Credibility of Scientific Literature

1. Is the source useful for supporting or describing your objectives?
2. Is the date of publication timely and relevant to your topic?
3. What are the credentials of the author?
4. Who is the publisher? Was the document reviewed before publication?
5. Is the language unbiased and objective?
6. If it is a report or review about scientific research,
    a. is appropriate literature cited?
    b. are the methods scientifically sound?
    c. are the data objectively interpreted?
7. If it is an electronic source,
    a. who is responsible for the publication?
    b. does it have links to other credible sources?
    c. which domain is used for access?

to your audience and your objectives. Credibility or reliability of the source depends on the quality of the research reported, the author and the publisher, and their purpose in publishing. Credibility is important no matter where you acquire a reference. Consider the points in Box 4.1 and the discussion of the numbered points that follows relative to each item you have collected no matter what the source is.

1. The source is useful only if it fits your topic, but it does not have to agree with your hypothesis or with the results of your study. It is equally as important to show information about research that has found results contrary to yours as it is to show that which supports yours. What you want to eliminate is any literature that is just remotely related and not strictly relevant to your topic or any that is not reliable.
2. The date when the document was written or published is important. For the most part, you should include the most recent literature with the latest findings about a scientific issue. However, do not discredit work done years ago. For some subjects, studies from 50 or more years ago may reveal findings important to your topic. Timeliness of the literature depends on the subject and whether you are doing a historical review of the literature. For example, studies on transgenic plants were not likely done 70 years ago, but work on plant identification was and may be important in a study describing or naming species.
3. The author does not have to be a renowned scientist. Good work is done by junior scientists and graduate students. But check the affiliation of the authors. Are they associated with a university or a reputable agency that does unbiased work? Scientists associated with for-profit organizations or special interest groups can also be unbiased, but they likely favor the group that supports them.

4. Professional societies and reputable publishers usually publish credible reports. However, they may also publish news items or lay magazines that speculate on possible breakthroughs in science that have not been clearly established with sufficient data. You can generally judge these by the format of the document or the intended audience. It is important that scientific manuscripts be reviewed by other scientists. Scientific journals provide information on whether their publications are reviewed, and most of them are reviewed. If the publisher is not a professional society or a journal is not reviewed and well-known, determine who that publisher is affiliated with and the reasons for publication. Language bias may give you answers.
5. Language bias is fairly easy to detect. If the author or publisher is trying to sell an idea or a product or is defensive or subjective about an issue, it is usually obvious in tone or the way things are written or not written. Be cautious with using any reference if opposing views are not considered, if the language uses emotional terms, if the language is exaggerated or flowery, if prejudice is evident, and especially if the work has no author identified or if any conclusions lack adequate supporting details and data.
6. Inaccuracy or incomplete disclosure can usually be detected in the scientific report simply by studying details in the literature, methods, and data. If authors fail to credit the appropriate literature or include that which does not concur with their finding, their report may be accurate but incomplete or biased. Determine whether their methods are scientific, complete, and reproducible. Were there adequate samplings and replications or repetitions in the study reported? Are the data objectively presented with applicable statistical design and analysis? Do the data clearly support the conclusions? Is the discussion objective and free of language bias?
7. The previous six numbered points apply to any source of information, whether it is from a scientific journal or book or an unpublished report or presentation. Be doubly cautious about information retrieved from electronic sources. A few additional clues are available to help determine credibility of electronic sources. First, determine what author and publisher are responsible for the information. Many scientific societies now publish journals online. Check to determine if the society is represented with the article you find. Check any links to other sources. If the work has no obvious author, publisher, and links to other sources, question the credibility carefully. Check the domain in the access address or pathway, but do not depend on the domain for reliability. These domains are listed with abbreviations such as edu, com, gov, net, or org. Unreliable information can come from any of these sources. For instance, org may be the American Medical Association, but it may also be a subversive group that uses the Internet for propaganda purposes. Also, edu is used to designate both highly reputable scientists and other employees or students of an educational institution who may have an agenda of their own. The design of a Web page or other Internet document may also give a clue to credibility. Serious organizations or other publishers may present

their logos or other attractive designs, but these are usually standard, subdued, and conservative. Graphic design and decorations, like language bias, can be used to call forth attention or emotion that can sell an idea or product. Be wary of such decorations.

In addition to these suggestions, Munger and Campbell (2006) provide some good checklists for determining credibility of online as well as paper sources. All this close scrutiny and evaluation of sources should not take too much time. Most reputable scientific journals are produced by professional societies or professional publishers, and they publish reviewed articles by reputable scientists. Scientific research done by government employees with the U.S. Department of Agriculture, the Department of Defense, or other agencies may be published as government documents. Generally, you can accept these publications for their intended purpose, but distinguish the purpose and the intended audience for materials published even by these sources. These publishers may also print information in lay magazines that does not contain the complete data you need to support your own contentions. They may also publish quick communications, letters, or proceedings clearly designed to disseminate information before research is completed and ready for journal publication. Distinctions in primary publication of research findings and early reports on work in progress or speculations on interesting applications for the research are usually obvious. As a writer, you should be discreet in your use of these publications.

Some industries, companies, or corporations publish trade journals or information brochures that can contain valuable information, especially concerning what equipment is available for doing research and development or instructions for use of a product you need in your study. Use these publications for their intended purpose, but accept in them a bias toward the company publishing the work without discrediting either that company or its competitors. Similarly, corporations may publish information for their employees to help them keep up with research and development. Such corporations or companies may also publish valuable educational materials for schoolchildren or the general public. Usually, if you can determine the purpose for the publication and the intended audience, you can judge whether you should reference a source in a scientific paper. The scientific writer must use clear discretion in citing publications. Your own credibility is at stake.

4.3.3 Using Unpublished References

In addition to publications on work completed, know what is being researched on your subject but not yet published. As you become involved with a profession, you will exchange information with your peers at professional meetings or by phone, with electronic mail, or through fax exchanges. Generally, you will never use another researcher's ideas and data until they have been

published and you can clearly reference them. With permission, you may sometimes use such personal communication as a citation in your own work. However, a bona fide, refereed publication is more likely to command the respect of your audience than is a personal communication. But verified communication from an expert on a subject can be valuable support to your paper. We can expect that the results from quality research should be and usually are published. If, however, the information is an isolated finding or a very recent disclosure, it may be important but not yet published. Personal communications can often supply you with information on papers in review or in press or with research projects underway. A fellow researcher can also refer you to literature you have overlooked or can help you perfect a method you are using. In association with your peers, you soon learn who is respected, and you aim for the same reputation. Your professional ethics must guide you in your openness as well as your confidentiality with your peers. Be sure you have written permission from your source and be sure your journal accepts personal communications before you use them. Careful documentation of your sources is always vital.

4.4 REVIEWS

Before you begin to write a review of literature, be sure you understand what constitutes plagiarism and how to avoid it (see Chapter 12). Document all information carefully, and follow a technical style sheet for specifications in textual citations and bibliographic entries (see Chapter 8).

Reviews bring together background information that integrates ideas from many sources or links other original research to your own studies. They can serve to justify your work, support your results, establish your methods, or simply add to knowledge on your subject. Published review articles can be valuable in that they summarize and blend the works of many researchers with comparisons of finding, theories, and ideas. You will understand your own work better when you not only have read and studied what others have done but also have brought their ideas and yours together. Literature reviews support proposals, theses, journal articles, oral paper presentations, and other reports. In addition to review articles, complete books, monographs, or journal articles can be made up of reviews of the literature. See Appendix 4 for a review written by then-graduate student, Terry Gentry, in conjunction with his research proposal.

Writing the review is no easy task. First, distinguish between the review that is published alone and the review of literature for your thesis, proposal, or journal manuscript. Once you have searched the literature thoroughly, you read and become familiar with what you have found. Probably at this point you will begin organizing your notes. Think in terms of the organization your review will take, and devise a complete outline or sections and headings for your notes to keep you on course. You may also be able to organize the

material from your search to correspond roughly with the intended organization of your review.

For most graduate students, the literature review will become a chapter in your thesis or a review for a proposal or journal manuscript, and the content should be based on your research objectives. Your notes might, for instance, fall into categories such as General Information, Methods in Other Studies, Support for Objective 1, Support for Objective 2, Similar Hypotheses, Results to Compare or Contrast to Mine, History of Subject, Pros and Cons of Controversy, and Also May Fit Somewhere. Note cards or loose leaves that can be organized and reorganized are handy for these notes, but if you prefer a bound notebook or the computer screen, you can develop a system for keeping up with the arrangement of your information. Certainly, computer software such as RefWorks or Endnotes can help you with a bibliography.

After you have become thoroughly familiar with the literature on your subject, the job of writing a review may seem formidable. Complex jobs are usually done best if you divide them into parts and attack each part separately. I have two suggestions.

Develop an outline. Your subject matter and your notes will govern the kind of overall organization. If you are showing how your subject has developed over the years, you will choose a chronological arrangement. Comparison and contrast can be used in reviews of controversial theories on a subject. If your research brings together several views on a subject, you may enumerate and describe the different discoveries and theories. Or you can use more than one of these approaches and organize on the bases of the subtopics involved. See Chapter 3 for information on organization. Whatever your organizational plan, have it in mind before you write.

With a format in mind that will accommodate chronology, enumeration of points, or other organizational design, look again at the headings you have given to your notes. You may now want to reorganize material, combine two parts, or separate one into two. In this reorganization, write down headings for the sections of your review. What you are doing, of course, is outlining. If the review is relatively long, you can organize the material for each section to make independent outlines of small portions of the review. You may want to make outlines of all the sections before you begin to write in order to see how they separate or connect. Parts can be combined or separated and reorganized yet again. All this organizing and reorganizing may seem time-consuming, but it may well save you some time in writing and rewriting and help to produce a better paper.

When you are satisfied with the organization of a single section, write that one, then another, and another until you have a draft of each. Then go back and put them all together being sure you have made comfortable transitions for the reader.

Create a skeleton. If outlines evoke screams of protest from you, do some free writing first. Think about topics that are most important to your review

and write down ideas on these topics. When you believe that you are comfortable enough with putting those ideas down on paper, take a few of the documents you have collected and write a short paper based on these. For a fair-sized review such as you may use in your thesis, as few as six or eight articles will be enough for this initial effort. Keep in mind your own objectives and organize the paper based on the main points of concern in your study. Discard anything that is not going to serve your objectives and the final draft.

With this minipaper written, you can now isolate and refine the main points and set up the sections of your full review. Don't scream; you have to outline or at least organize sooner or later. The free writing is for sorting things out so they will start falling into place. Now the information you have written from the few articles may need to be rewritten and arranged under the sections. This revision will serve as a skeleton of your first draft of the full review. You can now take information from other documents to add to or insert into what you have written about the first six or eight.

This method works well with the word processor in that you are revising and editing as you add and rearrange ideas from your literature. Word processing also helps you sort out a stack of literature and get information from each piece into the right places in your text. You may wish to cite the same paper in more than one section of your review. With an initial skeleton of your work on the screen, you can add to one section and then to another as you glean information from each source. After you have inserted the ideas from various sources into your paper, you will certainly need to revise to make smooth the flow of the language and the transitional progression from one point to another.

Outlining and creating a skeleton paper work quite well together. Whatever organizational technique your use, the draft will need to be revised to make the information flow to the reader in an organized manner. Ideas from Hofmann (2010), Day and Gastel (2006), and Silyn-Roberts (2000) can also be helpful.

A common problem in writing the literature review is that it can turn into a boring list of ideas in paragraph form. Make yours move from one point to another with discussion and transition. Use subheads (not too many), transitional phrases, and unifying ideas to make information flow smoothly. Spice your writing with variety. Recall all the times you have almost fallen asleep trying to read boring material. Keep yours alive. Vary the way sentences and paragraphs begin. And be sure to use an assortment of active verbs. Literature reviews can quickly wear down a handy word. It is boring to read "Author A found that …. Author B found …. What Author C found was …. Author D also found …." Other verbs can substitute for *found*. Try some of the following as well as others: Author A "found," "demonstrated," "presented evidence for," "suggested," "observed," "reported," "examined … and concluded," "noted," or "was convinced that …." Notice that each of these words has a slightly different meaning. For example, Author A may not have been completely "convinced that …" but simply "suggested that …." Choose the appropriate one. And vary the sentences by

beginning with something besides the author's name: "In a study on …," "Early in the 1980s, Author A …," "According to Author A, …." Or simply put the citation at the end of the sentence if that technique is appropriate. Our language is filled with active verbs and variations in sentence structure. Use them.

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Chapter 5

The Proposal

A new idea is delicate. It can be killed by a sneer or a yawn; it can be stabbed to death by a quip and worried to death by a frown on the right man's brow.

—Charles D. Brower

Your ability to write a proposal can be vital to obtaining a degree, getting a job, having adequate funding for your work, and advancing to higher positions. As a scientist, you will encounter two important kinds of proposals: the graduate research proposal and the grant proposal. Distinctions in the two exist because of different audiences, guidelines, and purposes, but both require similar planning, composition, and execution. The graduate proposal is a plan for you and your committee to follow relative to your research objectives, but the long-term benefits of the experience can be even more valuable to your career for writing grant proposals that support your future research. Developing skills in writing proposals is especially important for the young scientist who has not yet established a professional reputation.

5.1 THE GRADUATE PROPOSAL

A written graduate proposal serves at least three purposes. First, it is professional communication with an advisor and a committee. You are requesting approval and support to pursue a project. When the answer is yes, then the proposal serves as a contract between you and those granting the approval. The third purpose for a proposal is especially important to you. The contents become your plan of action and will serve as an outline of work to be done throughout the project and can keep you on track.

Whether or not a written proposal is required for a graduate research program, write one for your own sake. The proposal is important for helping plan the research in advance and to discuss with your advisors, to review what has already been done in the area, to foresee the pitfalls that lie ahead of you, to remain focused on a reasonably direct route between your proposed objectives and your goals, and to prepare for the inevitable task of writing grant proposals during your career. Another practical side effect in writing a graduate research proposal is that some of it will serve as drafts for your thesis and for journal articles. With modifications, the introduction, the initial review of the literature,

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and proposed methods will become parts of your thesis. With a clear plan or written proposal, the time needed to acquire a degree can be decreased. I was acquainted with two doctoral candidates who, as research assistants, worked hard, did a great deal of successful research for several years, and even published a manuscript or two, but when the time came to graduate, no specific thesis was underway, and they had several weeks of work ahead of them before they could complete the thesis requirement for graduation.

A graduate student proposal is not just a plan for you to follow; it is also a commitment to a departmental research program, to the graduate school that admitted you, and to your advisor. Your proposal is your commitment to make wise use of the time and resources available to you. Often in the scientific disciplines, the advisor, as well as the department and graduate school, has made an agreement with you to direct and financially support your research. If you fail to live up to your proposed commitment, you cost others time, effort, money, and progress in their work. Your proposal gives those with interest in your accomplishments some assurance of success by presenting a goal to be accomplished, rationale and justification for pursuing that goal, and feasible methods to accomplish the goal. Your job then is to complete the task. As DeBakey (1978) says, "It is a mistake to promise mountains and deliver molehills."

5.2 THE GRANT PROPOSAL

Many of the same admonitions that are true for the graduate proposal are also true for the proposal to be sent to a granting agency. The audience is different, and purposes may be motivated by the need for support for research or other projects or the stage of your career and by the desires of the granting agency rather than by the need for graduate education and an advanced degree. However, the same principles for writing and similar content and form are required. I suggest that the writer of the grant proposal carefully explore the wishes of the granting agency, be sure to follow its guidelines, and refer to a source such as Reif-Lehrer (2005) for recommendations for grant writing. Reif-Lehrer's experience is chiefly with large governmental agencies such as the National Institutes of Health and the National Science Foundation, but if you can follow suggestions for success with proposals to these groups, you can write for other grantors. Hofmann (2010) also makes suggestions for writing proposals, not only for government agencies but also for private foundations and individual grantors. Paradis and Zimmerman (2002) provide good information on preparing and writing the proposal.

Before you take pen in hand or put fingertips to keyboard, be sure you are ready to write a grant proposal. First, you must find the right granting agency for your particular proposal. Look into sources of information and funding in your discipline by checking online. Companies and corporations often mention possible grants on their websites. Government departments and agencies such as the National Institutes of Health, the National Science Foundation,

the Department of Energy, the Department of Education, and the Department of Agriculture provide their funding information online. When you have decided on a granting agency, you may still not be ready to write the proposal. Background research and literature review of your subject are time-consuming, but it will take you far less time to write a proposal and be successful with the research if you prepare thoroughly. Allow adequate time for both preparation and writing. Deadlines not met will kill the proposal before it is even considered; a late arrival will likely never be considered.

Be sure your idea is good and is appropriate to the funder's goals. If possible, discuss it with colleagues and with the funding agency's representative. Whether or not your reviewers are scientists, your proposal must be scientifically sound. Study the topic and the request for proposals from the funder. Outline a plan and review it carefully. Consider what personnel, money, equipment, and time it will take, and consider how this research will fit into the rest of your workload. Check with your employer to determine what the requirements are relative to your work and know how to fulfill them. Plan to have colleagues review the proposal; provide them with a tentative date you will have it delivered to them—well in advance of your deadline for submission. Review the granting agency's guidelines; study guidelines in Reif-Lehrer (2005), Hofmann (2010), or Paradis and Zimmerman (2002). Talk with colleagues who have had proposals funded. Devise a schedule; set personal deadlines for studying the literature, completing a first draft, getting it to reviewers, revising, developing a final document, and meeting the submission deadline. In other words, be informed and organized, and then write the proposal.

5.2.1 Content and Form

To have appropriate content to put into a format, you must have a good idea and clarify your thinking, plan and read background literature, and formulate hypotheses and objectives. Certainly you clearly understand what your objectives are, but DeBakey (1978) rightfully suggests that you write down the precise question you are setting out to answer as well as the expected results. Then proceed from there. Solidify your hypothesis and objectives while clarifying in your own mind what you want this research to achieve. Keep this focus through the other parts of the proposal. As you read the literature, watch for successes and failures that others have had with similar studies. You may be able to obtain copies to peruse of other proposals that have been funded.

For the graduate student, your proposal may be part of a larger grant your professor has already received. The proposal you write will be your proposed track to contribute to a part of that grant. Whether your proposal is a graduate research proposal or a grant proposal, form and content will depend on your intent and on the audience to which the plan is directed. For the grant proposal, private and corporate foundations and government agencies usually supply request for proposals (RFPs) along with detailed guidelines specifying the

order and length of the sections in a proposal; information that must be included; and even specifications for the font size, spacing, margins, and other elements of style. It is essential that you follow such guidelines. Many grants are competitive, and a proposal will likely be rejected before it is read if the author does not follow instructions. When a grantor receives 200 proposals and can provide grant funds for 10 of those, every detail is vital, including the appearance of the document. Be sure you have the latest update of guidelines from the grantor. The guidelines used in an earlier proposal will almost always be outdated.

Your graduate school, department, advisor, or granting agency may also be specific about a format or outline, but sometimes you have to devise your own organization. You can write a successful proposal by considering the characteristics common to all proposals and setting up an organization that will best convey those characteristics to your audience. Remember that communication is essentially a question–answer process. Producing a successful proposal requires judging what questions your audience might ask and answering them effectively. In other words, first consider your audience and the following criteria that will be used to judge your proposal:

1. Originality and scientific merit or benefit to the grantor's goals
2. Importance to the discipline or to the immediate problem
3. Feasibility
4. Rationale and methodology
5. Experience and qualifications of the investigators
6. Budget, facilities, and time required
7. Appearance and adherence to guidelines.

Your proposal should answer the questions inherent in these criteria. Is it worthwhile? What are the chances of success? Are the investigators qualified to do the work? What benefits will be derived? Are the expenditures of time and money realistic? The answers to such questions constitute the rationale or justification that serves as the basis for both the proposal and the subsequent research. Initially, if you are a graduate student, be sure the topic, question or hypothesis, and objectives are absolutely clear to you and that your advisor approves. For graduate or grant proposals, once you have identified the questions you are expected to answer and specified the objectives you plan to pursue, you are ready to set up an organization to accommodate those answers. Almost any proposal will include the following conventional parts:

1. Title page and executive summary or abstract
2. Purpose or hypothesis and specific objectives
3. Discussion of significance or need (justification)
4. Review of work done or being done (literature)
5. Materials and methods or experimental procedures
6. Discussion of possible outcomes (conclusions)
7. Time frame, budget, and curriculum vitae of investigator(s).

With these parts in mind, you can set up an outline for yourself or follow the format imposed by your committee or granting agency. Most likely, the funder will supply the outline and the guidelines with the request for proposals. If organization is left to you, remember that the best organization for one proposal may not be best for another. You may begin with a discussion of the need for the research rather than your purpose or hypothesis; you can even discuss possible outcomes in the introduction. You could start with a list of objectives and then build a case for pursuing them. The previous list is not an organizational outline but a mere listing of what you should include. Always be sure to follow any guidelines provided by the grantor.

A proposal for a graduate student's research may require writing a far more comprehensive literature review than grant proposals require. However, you may not need the budget, time frame, and curriculum vitae. You and your advisor or committee will have considered those questions relative to your program. But you should become familiar with the format that requires these items because they can be crucial for a grant proposal. Regardless of what format you use, you should include the following parts in whatever sequence is required by your guidelines.

5.2.2 Title and Title Page

The title should identify the specific subject in as few words as possible. It should attract attention to the hypothesis and clearly reflect the objectives of the proposal. Write a working title before you write the proposal to give yourself a succinct clear focus and then revise it after you complete the document. In the title, use only key words and avoid generalities or abstractions such as "A proposed study of the …." We already know it is a proposal.

The title page is an important first impression. Guidelines from the funding agency will outline the contents needed for a title page. In addition to a carefully worded title, this page will name the principal investigators and give their addresses, the date of submission, and the committee or agency to which the document is submitted. Many formats for grant proposals also require that the title page include information on the amount of funding requested and the time frame in which the work will be done. They sometimes require official signatures from not only principal and co-principal investigators but also a company or institutional official who coordinates funding activities. Some groups, such as governmental agencies, provide a rather complex form to fill out as a cover page for the proposal. Many of these are found online to be attached to your document either as hard copy or electronically depending on the submission requirements of the grant. They may require legal statements or questions to answer regarding such things as contracts, cooperative agreements, debt, and disbarment, all of which you must also sign. If you have no guidelines, or especially for the graduate research proposal, create your own neat title page (Figure 5.1).

Influence of Benzoic and Cinnamic Acids on
Growth and Survival of *Heliocoverpa zea* Larvae

a proposal

submitted in partial fulfillment of the degree of

Master of Sciences

by

Gerald L. Bjornberg

to

Graduate Committee

Department of Plant Sciences
College of Arts and Sciences

University of Tokenburg 1 January 2002

FIGURE 5.1 Typical cover sheet for graduate research proposal.

5.2.3 Executive Summary or Abstract

For the grant proposal, the executive summary or abstract is the most important impression you make beyond the title page. Make it concise but compelling. Its content is the basis for a decision to consider or reject the entire proposal.

The overall neatness of the proposal, the extent to which it follows a prescribed format, and the content of this summary will probably determine whether yours makes the first cut in a group of competitive proposals. For those 200 competitive proposals submitted, the executive summary may be the only section read before the 200 are reduced to a small number to consider for funding.

Your graduate committee may not require this summary, or the granting agency or your graduate committee may request an abstract rather than an executive summary. These two forms may be synonymous, but with either term what is expected is simply a concise description or summary of the proposed hypothesis, objectives, and expected outcomes. For the graduate proposal, you should be able to find a successful proposal written by a fellow student and pattern the abstract or summary after that if one is needed. For those of you seeking grant funding, follow guidelines with the request for proposals. If you do not have specifications, fulfill the request for an abstract or executive summary by following as nearly as possible the characteristics for the informative abstract (see Chapter 10). The difference in this summary for a proposal and an informative abstract written for journal publication is that completed results cannot be included. This omission allows more space for justifications and methods and expected results. Guidelines may dictate the length of this summary. The executive summary will emphasize objectives, hypothesis, justification, and benefits or application of results. Describe your project clearly and concisely.

The audience for the proposal may not be scientists working in your area. To reach this audience, be sure the executive summary as well as the entire proposal is clear and comprehensible to an educated, intelligent audience. Most important, the executive summary should specify the aims and design of the proposed research; be persuasive but objective; and emphasize benefits and clearly present substantial science, reasonable methods, and expectations.

5.2.4 Introduction

The organization of the introduction will depend on the audience and the development of the full proposal. Whatever form it takes, it should immediately show the reader the subject to be investigated or the question to be answered and give a rationale for pursuing the project. By way of identifying the relative scientific merit of the work and justifying its pursuit, the introduction may include some literature review, a brief account of any preliminary research done on the topic, and statement of benefits. It should include a purpose and suggest the scope of the proposed project. Most important, it should specifically define the question or hypothesis and list the objectives.

Do not let the word **hypothesis** disturb you. As used here, the word simply refers to a statement of the assumption you expect to prove or disprove, the question to be answered with the research, or the problem to be solved. It points toward what ideas can be credited or discredited when the objectives are satisfied. The **objectives** are specific goals that will supply the answer to

your hypothesis. They should encompass the aims of the research but be brief, precise, and limited in number and scope. Trying to include too many primary and secondary objectives can confuse the focus of your proposal for you as well as for those who review it.

The words hypothesis and objective are not always used with the same specific meanings that I have attached to them here. Others may use terms such as goals, aims, questions, or purpose rather than hypothesis and objectives. And some will require that you pursue a null hypothesis. For example, if you hypothesize that a certain gene controls skin color, your null hypothesis would be that that gene does not control skin color, and you would try to prove that it does not. If you do not succeed in proving the negative assertion, then a positive hypothesis probably would be true. Some researchers apparently believe that trying to prove a null hypothesis keeps them more objective and less prone to overlook or discredit findings that might prove the hypothesis wrong. However, all these differences in definition and in words used to establish a purpose in a proposal need not leave you frustrated. Simply check guidelines for your own proposal, ask your advisor for an opinion on what terms to use, refer to proposals by previous researchers that have been approved, and then stick to a consistent terminology in your own.

For clear justification and content in the proposal, be sure to distinguish between the hypothesis and the objectives in your own mind. Let me illustrate my definitions by following van Kammen (1987) in using Christopher Columbus as an example. If Columbus were writing a proposal for Queen Isabella and King Ferdinand, his title might be "Mapping an Alternate Trade Route to the Orient." His hypothesis would be that the world is round and that by sailing west he could reach the Orient and establish a new trade route for Spain and the rest of Europe. His objectives might be (1) to sail west and chart a route to compare to other routes and (2) to bring home three shiploads of spices. Notice the differences in the hypothesis and the objectives. The hypothesis is the general supposition and contains a preconception not yet proven. The objectives will determine whether the hypothesis is true, and they are the specific goals that will be achievable, if the hypothesis is true, by acquiring empirical data (distance and direction measurements) and tangible amounts of tea, cinnamon, and frankincense. These objectives have to be realistic and appeal to the grantor. Queen Isabella may have questioned how realistic they were, but both objectives would certainly be appealing to her. The same principles are true in developing a research proposal that appeals to an advisor and graduate committee or a funding agency.

Incidentally, while we are using Columbus as an example, let me call your attention to the observation that van Kammen (1987) makes about the "Columbus paradox." Christopher did not accomplish his objectives; his research hit a roadblock. He did not prove his hypothesis (although he thought he did), but his work made a definite impact on the Americas and the world. Further research on the same hypothesis did reveal a positive conclusion.

You have not failed completely and perhaps not at all if your research leads you to the West Indies rather than to China. Your discovery may be more important than if you had accomplished your original intent.

5.2.5 Justification

Justification, or rationale, is the key around which a proposal is built. It is the basic criterion by which the final proposal is judged. Justification permeates the entire proposal from the title to the conclusions with an appeal for approval and with evidence that the project should be pursued. Whether or not a specific section is given this heading, be sure that all sections contribute to the rationale that justifies the time, effort, money, and other support necessary to accomplish your objectives.

Justification outlines what can and should be done to accomplish beneficial outcomes. It shows how the methods can accommodate the objectives and how satisfying each objective will help to achieve the final goal. Justification describes the importance of your research to science and to the application of science. You can also justify your project in terms of its timeliness and economic significance as well as your own ability and access to resources to accomplish meaningful objectives. As an integral part of all sections in the proposal format, the justification will be based on the following:

1. Reason and logic
2. Preliminary research
3. Scientific principles
4. Research by others (literature)
5. Feasibility of methods
6. Use of or benefit from the results
7. Worthwhile use of time, money, and effort.

In some instances, your project may be partially justified on the basis of preliminary work you have done on a subject. If so, you may wish to present data you have collected and results that have come from your research and discuss how and why these results indicate that further work has merit. In fact, some academic departments do not consider your proposal until you have pursued some preliminary research, and some granting agencies are more likely to approve your proposal if you present results of a background investigation in your proposal. These research results still need to be supported by scientific principles and the literature. The example in Appendix 5 represents this kind of graduate proposal.

5.2.6 Literature Review

For the graduate proposal and to an extent for most grant proposals, the literature review should consist of a summary of the ideas of others that are pertinent

to your project. It can review the history of your subject or the present status of your research; it should consider any controversies surrounding a question or gaps in available information that you intend to fill with your work. It may introduce methods that will make your project possible. A good literature review can help establish your credibility and increase your chances for having a proposal accepted by illustrating that you know what has been done, what is being done, and what needs to be done in an area. You should cite work being done and recent publications from other institutions as well as from your own to establish the relationship between your proposed project and that of others. Be sure that all discussion is relevant to the specific objectives and the general hypothesis. For most proposals, keep all sections, including the literature review, brief to hold the reader's attention to your objectives. For a graduate proposal, some advisors expect a lengthy review of the literature because they want you to study your subject extensively to understand your own research better. In other graduate proposals and in grant proposals, the literature review may not be a section in itself but, rather, a part of the introduction and justification and included as citations appropriately placed in methods or discussion and conclusions. Ask your advisor or follow guidelines and examples of previously approved proposals.

5.2.7 Methods

In the review of literature or in the methods section, you will increase your credibility if you point out methods that you or others have used with or without success. The methods section, often called "Plan of Operation," "Materials and Methods," or "Experimental Procedures," is the very foundation of the scientific merit and feasibility of the work. To convince your audience that your plan is feasible and to serve you in pursuing it, the methods section should outline the working plans in as much detail as possible. Include information on materials, sampling, analysis, data, and even people you will need to work with; steps you will take in conducting the project; data you will collect; and how you will analyze and use the data collected. Describe any limitations or potential problems you may encounter and tell how you will address these. In a grant proposal, suggest alternative methods that you will use if those pursued first do not succeed. Procedures should generally follow the same order as the objectives and show how each objective will be attained. All materials and time needed should be justified in this section and reflected in the budget of a grant proposal. To the granting agency, this section should justify the budget. Some funders may require a specific section on budget justification.

5.2.8 Conclusions

Although you may have no results and little discussion beyond that described in previous sections, reemphasize objectives and draw the reader back to the

question, the hypothesis, the objectives, and benefits that can be derived from your work. Your conclusions will summarize points of justification. As in the introduction or executive summary, to further justify your proposal, this section can extend into proposed applications or future research beyond your own, but do not go far beyond the scope of the proposal.

5.2.9 References

The reference section is essential to your proposal. References with full titles indicate the extent to which you have explored your subject and are helpful to reviewers in their considerations. Although all important sources should be listed in your references and cited in the text, padding with citations only incidentally concerned with your proposal will not impress your reviewers. Both your graduate committee and some of the reviewers for grant proposals are likely familiar with the literature published. In fact, some reviewers may be authors of papers you have cited, and they will quickly recognize omissions, padding, or errors in your references. The citations and references must be accurate and follow a consistent style throughout. Any error can damage your credibility and diminish the chance for acceptance of your proposal. Chapters 4 and 8 provide further suggestions about use of literature.

5.2.10 Budget and Time Frame

For a grant proposal, the most important issues can be time and funding requests. A grantor may be fully convinced that your scientific proposition is feasible, but an unrealistic budget or time frame can negatively influence opinions of reviewers. Just as some people ask for too much time and money, some do not ask for enough. Be realistic in your needs. As DeBakey (1978) says, "Honesty and common sense are the best guides."

As a graduate student or a beginning scientist, you may have little experience with budgets for funding a proposal. Graduate students should discuss issues of costs with their advisors. The university may also have an Office of Sponsored Programs that will be helpful with information on allowable costs, matching funds, overhead, and other indirect costs relative to the proposed research. A company you work for may also have regulations on its responsibilities relative to costs of proposed projects. Be sure you are in compliance with any regulations of your institution or company relative to your budget.

With these precautions in mind, plan the budget carefully with estimates as nearly accurate as possible. You do not know exactly what your supplies will cost, but if your research has been clearly outlined, you can provide a reasonable estimate. Include salaries, equipment and supplies, publication costs, travel to collect samples or to take results to professional meetings, and even phone bills. Do not forget indirect costs or overhead if your company or institution charges such a fee. Often, overhead is a large percentage of the total costs; 20%, 40%,

and even higher percentages for overhead are not unusual. On the other hand, some agencies may not allow such indirect costs to be budgeted.

Some grants are made only if the employer matches the value of grant funds in money or other resources. In this situation, you will need to include in your proposal a statement on these contributions. Describe the facilities and equipment that your employer will contribute to carry out the project. Also note the percentage of time the investigators and other staff or hourly workers will spend with the project and consider percentages of these salaries as part of the employer's contribution. Be sure your budget is in agreement with the negotiated costs between your employer and the funding agency. Finally, check and recheck. Be certain that your budget column totals are correct. Funders often find mistakes, and such errors make a poor impression on your credibility.

Time may be as important to your grantor as money. Allow yourself enough time, but do not be wasteful. In asking for time, justification in the body of your proposal is critical. Some experiments take longer than others. If you are doing laboratory analysis that takes just 5 weeks to produce each data set and you are supplying 10 data sets, you might reasonably complete your proposed research and all the reports involved in 1½ to 2 years. However, if you are doing fieldwork that must be repeated over the environmental conditions of 2 or 3 years, you can justify additional time. With both time and money, the key word is realistic.

As a graduate student, you may not need to worry about your budget and time frame. Your advisor can do enough worrying for both of you. You simply accept the support available and work to complete your degree on schedule. Your proposal concentrates on what you will do rather than how it will be financed. Your advisor may ask you to prepare a timeline for the steps in your research program, or the timeline may be dictated to you. At some schools, you must finish your program within a certain time or your research support will no longer be available to you. Within this time frame, you can set a more specific schedule for progressing through it. Then, you work within the limits provided for time, money, and graduation dates.

5.2.11 Biographical Information

For your graduate proposal, you will not need to provide biographical information because your advisor has already looked into your credentials with your application to graduate school. But for the grant proposal, a **curriculum vitae** is usually essential for you and for any co-principal investigators. Be sure to make clear in this abbreviated resumé that you are capable of doing the proposed project. Emphasize points in your training and job experience that have to do with the expertise needed, and avoid an extensive presentation of points unimportant to the plan.

5.3 OTHER CONSIDERATIONS

Proposals are likely to become a vital component of your career as a scientist. In graduate school, if you are employed as a graduate assistant or a research assistant, you may assist in writing grant proposals other than for your own research. For example, you might be asked to assist with a proposal extending research beyond the limits of your own program or pursuing another avenue of research in the same discipline. Working with any proposal is a valuable experience for you, and it will teach you much about the proposals you will produce in the future.

As with any important document you compose, your proposal should go through a process of reviews and revisions. Invariably, you must meet deadlines for submission of proposals. Write drafts in plenty of time for reviewers to make suggestions and for you to revise the proposal. Whether a proposal is invited or competitive, be neat and direct, follow guidelines, and be realistic. Your ability, the time needed, the resources available, and the money granted must all add up to probable success of a proposed project. If these things are not treated realistically, all the good scientific ideas in the world will not yield a successful proposal.

Despite all the work you put into writing proposals, many of them will be rejected. Reduce your frustrations by recognizing the beneficial side effects to writing unfunded grant proposals or even the graduate research proposal that your committee does not approve. Something positive often comes despite the rejection. Think positive. You have a good idea. In writing the proposal, you pursue the subject in-depth. You learn much from the literature, you learn who else is working in the area and often get acquainted with people with whom you will work in the future, and you practice your skills in writing proposals. In the face of a $250,000 rejection, these benefits may seem trivial, but in the big picture they are important to your career. Proposal writing is a way to keep current with what is going on in your field; it prompts you to read the literature and to consult and cooperate with your colleagues. In addition, the rejected proposal should serve as a semifinal draft for resubmission to your graduate committee or to the same funding agency or another. Often, the funding agency and certainly the advisor or graduate committee will provide review comments that can help you in revising the document for submitting a more acceptable version the second or third time. You may need to request the review comments from the agency's program officer. Consider revision and resubmission a part of the overall grant writing process.

Finally, as important as obtaining the approval or funding for your work is the execution of the work. As you get into the project, you may find that you have to revise the proposed plan. For instance, you may find a different method or new equipment will become available that provides better results, you may discover evidence that must alter your original hypothesis, or specific equipment could become inoperable just when you need it. Your original

proposal will not guide you through all the possible problems and discoveries that occur. Remember that the funding agency must approve changes to the budget that move funds between categories. Do not shift money from one area to another without understanding the limitations on the funding. You must be creative enough to find a new path and execute the plan regardless of obstacles. Explanation of these obstacles and how you overcome them should be incorporated into progress reports.

5.4 PROGRESS REPORTS

To keep their records updated and because the unpredictable is to be expected, many grantors and graduate advisors require periodic progress reports. These reports protect your credibility. Be sure you submit the reports on time and clearly explain the state of the project, what has been accomplished, and the proposed next steps. If you have had problems, report them but do not be too pessimistic in these reports. Be positive, but as with all the details in your proposal, be realistic. Instead of saying, "We were not able to complete this experiment by April," say, "We should complete this experiment by June." Then explain any hurdles that prevented finishing by April and how you plan to address them. Grantors and advisors are generally reasonable people. They need to know that you are doing the best job possible in carrying out your proposed project.

The progress report may be as formal and as important for a granting agency as the proposal. It also may be as difficult to write. Granting agencies want quality assurance that research is being carried out with sound scientific accuracy and their funds are being used appropriately. They may renew your funding for an extension of the project if they like what they see. Again, be positive. If you have faced obstacles and overcome them, they may admire your efforts; if you have given up in the face of obstacles, they may not want to risk their funds with you again. Silyn-Roberts (2000) provides some checklists for preparing progress reports. Any intermediate progress report will be valuable as you write the final report.

A final progress report can also help you with that final step in most projects—the publication or thesis or the new grant proposal. No project is complete until this final report is done. This report is evidence of your accountability by demonstrating that the time, money, and resources have been used well. Among the characteristics that are scrutinized in a beginning scientist is the potential for good grantsmanship or "the art of getting financial support (a grant) for your research" (Stock, 1985). Your ability to communicate through the proposal and in a final report, thesis, or publication and a new proposal is an important component in this art and absolutely vital to your career as a scientist.

If you are not following a prescribed format, you should explore differing opinions of others before you begin a proposal. Check what Peters (1997) has to say about graduate proposals. Silyn-Roberts (2000) provides good information on writing proposals and progress reports. Reif-Lehrer (2005) gives detailed

suggestions for writing grant proposals to large funding agencies. Goldbort (2006) includes some examples of parts of a proposal in his book, and DeBakey (1978), Hofmann (2010), and Paradis and Zimmerman (2002) discuss basic strategies for proposal writing. A sample graduate proposal is in Appendix 5. Regardless of whom you consult for information, be sure you follow the guidelines set forth by your graduate committee or the funding agency.

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Chapter 6

Graduate Theses and Dissertations

Camante, no hay camino, / Se hace camino al andar.
(Traveler, there is no path, / Paths are made by walking.)

—Antonio Machado

6.1 THE THESIS AND YOUR GRADUATE PROGRAM

Except for works of rare genius, a thesis or dissertation cannot be produced in a week or even a month. (I will use *thesis* to mean either thesis or dissertation unless it is preceded by *master's*.) The thesis is the final report on the research that you pursue throughout your graduate program. To make the most conservative use of time, coordinate the writing with activities such as course work and professional meetings as well as the research itself. Drafts of literature review, methods, results of individual experiments, and preliminary conclusions can all be written as your work progresses. Any drafts that you have started or completed early will make those last months of your program a great deal easier.

As you get into your graduate program, develop a tentative time line with dates of proposed milestones from the beginning to your expected graduation date. Be sure to review the policies of your institution regarding due dates, committee requirements, and other procedural issues that can impact your time line. Along the line will be as much detail as you can enter, and you will revise it as you proceed through your degree program. Figure A6.1 in Appendix 6 is a hypothetical time line that can serve only as a model. Yours must be individualized and will include a greater number of specific details. Coordinate the milestones with times for course work, the steps in the research itself, graduate exams, job search, making presentations at meetings or in your department, and whatever else fits your individual program. If you find it difficult to juggle all these activities, read Molly Stock's (1985) book, *A Practical Guide to Graduate Research*.

The thesis is the document that records your research efforts and the results of them and reflects what you learn along the way. Characteristically, your

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thesis should be built upon knowledge you have gained from the following:

1. A complete review of literature—on what has been done on your specific research topic and closely related subjects
2. Your original research or professional project—field and laboratory experiments based on a research proposal or project as approved by your advisor and graduate committee
3. Your syntheses—putting together and deriving meaning from your data, ideas from others, and your own conclusions.

Neglecting any one of these foundations for your thesis will limit the quality of your work. Success depends on your knowledge of the literature, meticulous work with your own research, and your efforts to give a clear, accurate perspective to the entire study. When these points have been given appropriate attention, the other criterion for success is communication—the writing itself.

Expectations for both master's and doctoral theses are inconsistent even in the same discipline. Common requirements are set forth by the department, the college, and the graduate school from which you get your degree, but your advisor, your committee, and your degree program may specify other expectations. As you begin your graduate project, check on any criteria for theses from your graduate school and department, talk with your advisor and committee members, and peruse several theses that have been produced in recent years by respected graduates from your department. In other words, get a clear feel for what your thesis should be long before you write it. What you do during the first few weeks of your graduate program to understand what is ahead can make a major difference in the time it takes you to finish the degree. The format your thesis takes may be one or more journal manuscripts with or without additions such as a general introduction, proposal, appendices, and an overall abstract. The thesis can also be a traditional form not designed for immediate publication. Whatever the form or style, the contents of your thesis will typically include the following:

1. Introduction—general justification for the study, the hypothesis or question behind the research, and a specific statement of objectives
2. Literature review—a detailed report of what has already been done on your subject (sometimes combined with the introduction and included as content in journal manuscripts)
3. Materials and methods—an account of the specific techniques used in the study, including materials needed, procedures, statistical design, and data collection and analyses
4. Results—a presentation and meaning of the data acquired from your research
5. Discussion—significance of your own data as well as the relationship between your work and the findings of others (results and discussion are sometimes combined)
6. Conclusions—a summary of your findings and their significance and perhaps suggestions for further research or applications for the findings

7. Bibliography—references to the literature used
8. Appendices—related material that supports a point and provides additional information but is not essential for understanding the thesis itself
9. Abstract—required for doctoral dissertations and may be needed for master's theses.

Writing the thesis will be easier when you visualize a clear picture of the content and organization involved. As with your proposal, the content of your thesis will present a question or questions to answer or a problem to solve. You will establish objectives for your study by talking with advisors, reviewing the literature, and suggesting a hypothesis or answers to the questions involved. (See Chapter 5 for distinctions between *hypothesis* and *objective*.) If your proposal is carefully written and followed, it can become a foundation for the introduction, literature review, and methods sections of the thesis. Once you have tested your hypothesis with your methods, you can report and interpret results relative to the original questions or objectives. With a vision for the format and contents of your thesis in mind, consider use of the following resources.

6.1.1 Graduate College Requirements

Most graduate schools furnish information on requirements for graduation in a published or online catalog or in a guide for preparing theses. Keep these instructions handy and check for updates periodically. There are deadlines to meet and fees to pay. Requirements for both the college and your department include deadlines; committee composition; and technical details for the thesis, such as margins, type font, spacing, and the kind of paper required. Knowing these things ahead of time or having a guide to refer to will help you avoid problems later.

6.1.2 Style Sheets

For technicalities in the composition, another important guide is a style sheet. For points of style beyond those specified by your department or graduate school, the discipline in which you are working probably has a style to which it generally adheres. *Scientific Style and Format* (Council of Science Editors, 2006), *The ACS Style Guide* (Coghill and Garson, 2006), and the *AMA Manual of Style* (Iverson et al., 2007) are convenient references for various disciplines on points of style such as abbreviations, punctuation, and bibliographical style. Other scientific groups, such as the publisher to whom you will submit manuscripts and government agencies and associations, have specific style requirements. *Scientific Style and Format* (Council of Science Editors, 2006) contains a list of style manuals for scientific disciplines. If you do not know which style to use, ask your advisor. Sometimes your advisor or committee will recommend that you choose a professional journal in your discipline and follow its style. Styles for publications differ with journal editors or publishers, but most provide "Instructions for Contributors" or other style sheets to follow. Become

familiar with the style of your professional societies and have a style sheet handy. For further information on style, see Chapter 8.

6.1.3 The Library

The sooner you get acquainted with a library, the more time you will save yourself. The simplicity or complexity of your literature search will depend on your knowing what you want to find and how to find it quickly. Also, be quick to question the value and reliability of the sources you find. Some literature can be found and read through the Internet. Your library may have a librarian who specializes in your field. That person can help you navigate the manual and online indexes available and will be a valuable resource throughout your program. More information on the literature search and on evaluating sources is in Chapter 4.

6.1.4 Your Advisors

Your major advisor is probably your most valuable resource. Take advantage of his or her expertise. Be independent, think for yourself, and find answers to questions with a graduate school catalog, a style manual, or other resources, but report to your advisor regularly too. Because departments and graduate divisions differ in their requirements for theses, I cannot provide the final word for what your thesis should be. Your advisor has many of the answers, but also consult the persons in the department who know answers regarding policies and procedures. This may be your advisor or it could be an administrative assistant or staff person. In addition, your other committee members can be valuable consultants as you proceed with your study. Each is on your committee for a particular reason. Get acquainted with them early, visit with them periodically, and use their expertise. If possible, take a class with each one to learn more about them and their interests.

6.1.5 Other Professionals

You may need to work with specialists in addition to your major advisor and the committee. For example, your thesis will most likely contain quantitative data, and a statistician may be available to consult even as you plan your experiment and collect the data as well as when you complete the analyses. Formulating the design for your experimentation and stabilizing your plans early in your research can pay big dividends in both time and research quality later. You may also have available a writing center or someone with expertise in writing, revising, and editing. These experts can prove valuable in getting the thesis put together well. Think for yourself, be independent, but do not hesitate to use all these people and sources of information to assist you with your work.

6.2 AVOIDING PROBLEMS

Your thesis is the written record of your graduate research project and should contribute substantially to your professional reputation and your discipline. It will probably form the basis for a final graduate defense or oral exam by your committee. Building and maintaining your reputation with your peers, faculty, and other professionals in your discipline will depend on not only how good the final product is but also how you handle problems along the way. The proposal, your research, cooperation with others, and the thesis will illustrate your scientific acumen and professionalism. How well you integrate these individual activities will determine, in large part, how successfully you complete your degree and what kind of recommendation you will get from your department when you apply for a position.

Weeks, months, even years of delay can result from poor planning and execution of the graduate research project and thesis writing. You may want to read *Getting What You Came For*, particularly Chapters 17–19 (Peters, 1997), before you get too far into your program. Work closely with your major advisor but assume full responsibility for your program. Do not wait for the professor to tell you to write a proposal, search the literature, and write a literature review. If these chores are not required by your department, you will be ahead to do them anyway. Work both cooperatively and independently, but do not get so independent that you step across the line of diplomacy and discretion. The department has policies, and you are probably using resources that belong to your department. The advisor may be supporting your research from funds designated to accomplish specific goals, and your research must contribute to those goals. Consult with your advisor before taking drastic steps. As you become acquainted with departmental procedures and the personalities you work with, you will be able to determine how much independence you have. The following suggestions can help you avoid pitfalls common to graduate students.

6.2.1 Get Started Early

The responsibility for getting the thesis finished is yours alone. From the day you begin a graduate program, planning for your thesis begins (see Appendix 6, Figure A6.1). Decide very early what area you want to work with so that your advisor, your course work, your exploration in the library, and your research in the laboratory or field can be chosen with the specific objectives of your thesis in mind. If you realize as you get into your topic of research that it is not really the subject you would prefer to pursue, consider your options and objectives, but do so early in your program and be sure you make any changes in a professional manner. If your major advisor has agreed to support your project financially, it may be that the funds he or she is using come from a grant that requires the pursuit of a specific topic. If you have agreed to work on that project, it may be that the advisor can no longer support you if you change your

thesis topic. Changing advisors, changing topics, or even changing majors is possible but not recommended, and once you have written a proposal that is accepted, remember that it is a contract and withdrawing from that contract affects your major advisor and your department as well as your own pursuit of the degree. Breaking any contract, whether or not it is a legal matter, is detrimental to your reputation. Talk with your advisor and other professionals and make any change smoothly and professionally.

6.2.2 Maintain Professional Relationships with Your Advisors

Recognize that advisors are humans with unique personalities. A single graduate student is probably not the primary focus nor the only student they advise, but they should be actively involved with all their students including you. Most advisors are attentive to their graduate students, but do not be offended if your project does not take precedence over their many other activities. If your major advisor is sometimes too preoccupied to help you, take charge of your own destiny, with finesse and discretion of course. Work cooperatively but do some independent thinking too. That is part of being in graduate school. If you assume your own responsibility for your program, you should finish your degree on schedule regardless of how much or how little input the advisor contributes.

Professors are abused in two ways: You ask too much or you ask too little. You waste time with questions you could answer by consulting a dictionary, a college catalog, or a style manual. You can waste time for the professor with bits and pieces of your thesis that are too fragmentary or difficult to read, with too much casual talk, or with too many intrusions into busy schedules. However, graduate students also abuse their professors by avoiding them. A casual question or remark, a handy reference you find at the library, a personal revelation—these things can be important to the advisor's knowing you and your subject. The professor has an interest in your work and a responsibility to work with you. Maintain a constant, congenial, and professional relationship. Your work is important. Consultations on courses you should take, subjects of common interest, your research and your thesis—all are important for both of you, and advisors do not feel that such things are a waste of time. Discuss such issues as your time line, your responsibilities, and your position as author of any publications that come from your research. Certainly, the research for your thesis and the writing of it are points that bear repeated discussions.

6.2.3 Draw Up a Carefully Planned and Well-Written Proposal

An attempt to pursue graduate research and produce a thesis without a written proposal is like taking a trip through unfamiliar territory without a road map. You may find your way and even be successful, but most likely you will waste time, have to double back over some roads, go down blind alleys, and even get lost.

Working out hypotheses, objectives, justification, literature, and methods for the proposal will sharpen your perception of your subject. The written proposal provides an early draft or outline of the thesis, and it will serve both you and your graduate committee in communicating and keeping on track. If the written proposal is not required, write a draft for yourself and take at least an outline of your plans to your professor. Be sure to include specific objectives and a hypothesis as well as some information from the literature and suggestions for specific methods. These things show the advisor that you are really ready to begin research. Ask for advice and then suggest that you submit the entire proposal to your committee and meet with them for their opinions. Your advisor will likely be pleased that you are assuming responsibility. Be ready to accept or at least discuss his or her modifications to your plan.

6.2.4 Maintain Accurate, Complete Data

All data you collect should be considered important. Gather them carefully, write them legibly, analyze them thoroughly, respect their revelations, and then store all of them, not just the part you use. Read Macrina (2000) on keeping scientific records. Do not trust your memory. A short pencil can be more reliable than a busy brain. Write down field plans. Write down chemical analyses. Write down techniques and amounts you use. In field observations, record the weather. Record full references from the library with page numbers and full names. Using *et al*. can get you in trouble. Your good memory cannot always fill in the blanks.

In addition, for many of you, a camera can help record data. Have access to a quality camera and use it often. Pictures you take can be important in showing methods and results of your research and can often be used in the thesis and certainly in slide and poster presentations. For these formats, you will likely want color, but for publication you may still want black-and-white photographs.

6.2.5 Write the Thesis as Your Work Progresses

It would be a formidable task to write the whole thesis at one time. But you can divide the work into logical portions (see Appendix 6, Figure A6.1). Both Peters (1997) and Bolker (1998) suggest that you write some every day. I agree. Before you begin your research or when you write the proposal, you should make a complete literature search and write a rough draft of the **literature review**. At this point, you can compile a first version of your **references**. When you set up your proposal and plans for research, you can also write the **materials and methods**. As portions of your research are finished, you can draft the **results** and **discussion** section(s). All of these sections will require revision, but the easiest time to write first drafts is when details are fresh in your mind. The **introduction** and **conclusions** can be the last sections you write.

The introduction may be a modification of the introduction to the proposal. The purpose for the introduction is to direct the reader into the thesis; the conclusions need to focus the reader's attention on your most important findings. You can best accomplish these purposes after you see where you have been.

6.2.6 Be Proud of the Final Copy

Be certain that the content of your thesis is something you can be proud of by doing a meticulous job with your research and by having a thorough knowledge of what others have done and how your study complements or adds to the established literature. Write a clear, well-organized, and developed text. Make the appearance of the document attractive and professional. Choose details such as font and spacing carefully. Your name stands alone as the responsible author.

6.2.7 To Publish Is to Build Your Reputation

The best time to publish is when your research and data are new in your mind. Sometimes, but rarely, a doctoral dissertation can be published as a book or monograph. You may want to register a copyright for your work. If your work is a doctoral dissertation, your graduate school may require publication of an abstract with Dissertation Services (UMI Dissertation Services, 300 North Zeeb Road, Ann Arbor, MI, USA 48106-1346). The graduate school office will probably take care of submitting the abstract for publication.

Whether or not you copyright or publish your entire thesis, you should consider publication of your research results as journal articles. If possible, have a journal manuscript or two ready to send or already en route to a publisher when you graduate. From your thesis, you can choose the most significant data and arrange them to comply with the format of a given journal, or your advisors may encourage you to include in your thesis the manuscripts ready in the style of the journal. If you postpone the effort to have your manuscripts ready for submission, you often never carry out the task simply because it becomes increasingly difficult as time passes. You will have new goals involving your career that do not allow time for revisiting old data. Without extension of your materials into an active journal, much of your valuable data can grow stagnant in your thesis sitting on a library shelf. Work toward publication from the beginning of your program.

6.2.8 Last-Minute Jobs Can Delay Graduation

After your thesis is written to your satisfaction, final chores will take more than a couple of weeks. They could take months if they are not accomplished in an efficient and timely manner. First, revisit the guidelines that you perused when you began this thesis project. In preparing for your final committee meeting or defense of your thesis, be sure to get copies to committee members

well in advance to give them plenty of time to read and evaluate your written work. If possible, you will want to visit with each of them individually for specific suggestions before the final meeting. New suggestions invariably come from individual committee members and their joint considerations. Allow time after their reviews and the defense to change entire sections and particular details.

When you have polished your thesis by incorporating the suggestions from committee members, the procedure for most disciplines requires that you take to each of them your letter-perfect thesis along with three or more copies of a signature page for final approval. You may be lucky. You may get the signatures in 2 hours. However, 5 days later you may be still trying. One committee member is out of town collecting research specimens, another is at a meeting in London, and a third just happens to be out of the office every time you check. Still another committee member would like extended time to look over the revised thesis before signing it. That person is probably not being disagreeable nor harassing you. Advisors should thoroughly understand what they are signing. Their reputations and that of the department, college, and graduate school, as well as your own, are at stake. Although almost any student wishes for quick approval of the final thesis, serious students know that their own degrees and reputations are far more respected if permissive is not the key word in the reputation of the department from which they graduate. The professor should check your thesis a final time and ask for further alterations in text, if needed, before signing the approval page. This careful scrutiny only adds to the quality of your final product.

The last minute has now evolved into days or weeks, and you still are not finished. Proofread and double-check your graduate school instructions to be certain you have followed all guidelines. When you deliver copies to your department, the library, or the graduate office, your thesis can be rejected if you have not been careful enough with details. Along with the thesis, you may need copies of a copyright release that you have to sign to allow library personnel to reproduce your work for research purposes. Because this signature must be yours, do not leave your thesis with a friend to hand in without signing the forms. Obtaining original signatures can take days and delay your graduation if you are pushing deadlines to their limits.

With your thesis delivered to the designated offices, you are almost finished. You should offer a copy to your advisor and even to committee members who have special interest in your subject. You may want a bound hard copy for yourself. You will probably not want it in sight for some time, but someday you may even display it—at least on a bookshelf at your home or your office.

6.2.9 Finish Before You Go

The last months of your graduate program can be hectic. In addition to getting the thesis in a final form and completing other requirements such as a

defense and a departmental seminar, you probably will also be searching for a job. Job offers may come before your thesis is ready to turn in. If you accept a position, arrange to begin work only after the thesis is complete. The new job will require your full attention, and even if you have time in the evenings, you will find it difficult to focus on the thesis. With your attention to the job and your new living situation, the thesis is not at the forefront of your mind. The psychological and academic influences of being near your major advisor, other graduate students, and research facilities such as the library and the lab are important to your maintaining a focus on the thesis. Former students who have tried taking the incomplete theses to jobs repeatedly implore me to advise other students not to do the same. Finish before you assume the next position in your career.

6.3 PLANNING THE THESIS

A first step in planning your thesis is to determine the form you will use. Your choice of form depends on the content of the thesis and whether or not the work can be published as a monograph or as journal articles. The choice also depends on what is acceptable to your graduate school, department, and committee.

In reference to forms for doctoral dissertations, the Council of Graduate Schools (2005) notes that some institutions accept as a thesis one or more published journal articles or manuscripts to be submitted for publication. In those instances, the Council states, "It is often required that the candidate include introductory, transitional, and concluding sections in order to achieve a more coherent and rounded piece of work." Other characteristics highlighted by the Council describe the dissertation as "highly professional training" and "an original contribution to knowledge in the field." However, most of the characteristics required and the form acceptable for the dissertation rest with the department and graduate school wherein the work is done. Requirements for the master's thesis are even more flexible and diverse and are determined by the graduate school and department at the institution you attend. For the master's degree, some do not require a thesis but, rather, extra hours of specialized course work or special projects. Determine what is acceptable in your department before you plan your thesis. Discuss form for the thesis with your major advisor early in your program.

6.4 FORMS FOR THESES

The same basic outlines for traditional theses or those incorporating journal manuscripts will fit both the master's and doctoral levels if a clear understanding exists regarding the differences and the educational requirements for each. Consider the following possibilities, but keep in mind that these are only

suggestions and you must learn whether your preferred format is approved by your advisors and your graduate school.

6.4.1 The Traditional Thesis or Dissertation

Basic outline

Introduction
Literature review — May be combined
Materials and methods
Results
Discussion — May be combined
Conclusions
Bibliography
Appendices

Samples of well-done traditional theses in your discipline are available in any university library. Goldbort (2006) discusses the traditional dissertation and provides a guide for the composition of the various parts by following the IMRAD format. This form can fit the research and content for many theses, and you and your advisor may prefer it. It can include one or several objectives and the ensuing research that can later be published as journal articles. Another possibility for the traditional thesis is that with exploratory research suitable for a master's degree but with data inadequate for publication, this model can be used with the required literature review, a clear presentation of all procedures and results, and perhaps suggestions for additional research that may ultimately lead to publishable information.

The traditional thesis will typically follow the previous outline, but reasonable creative alterations are not only acceptable but also often commendable. Some schools may recommend length, but keep in mind that unless a minimum length is required, for any thesis format you choose, the length of the thesis is essentially irrelevant. Some studies will need a 200-page report; others would be padded if they went far beyond 50 pages.

6.4.2 Theses or Dissertations Containing Journal Manuscripts

The thesis styled with journal publications in mind can be a compilation of manuscripts, which can be excerpted to be published, as well as sections such as the literature review and an introduction and conclusions that bring together your entire study. If this thesis format is planned from the beginning of your study,

much of the writing can be done before your research is complete. The literature review and its bibliography will need only to be updated at the conclusion of your program. Each journal manuscript can be partially written as you recognize which objectives and methods will be included in it.

Basic outline

Introduction
Literature review — May be combined

Journal article I—style of a specific journal

- Abstract
- Introduction
- Materials and methods
- Results and discussion
- Literature cited
- Tables and figures

Journal articles (ad infinitum) journal style

Complementary studies—for auxiliary, preliminary, or supplementary work not suitable for journal publication

Conclusions

Appendices

6.4.2.1 The Master's Thesis Including a Journal Article

For the master's candidate who has produced findings for a journal article but has acquired supplemental material that should be recorded in a thesis, I suggest the following possibilities. (The thesis will not necessarily be written or arranged in this order.)

1. Write a complete review of the literature when your proposal is designed and before your research is done. You will update this review as you finish your degree program, and it can become a separate chapter or a major part of the introduction to your thesis.
2. After your study is complete or as you complete the analysis for data sets, write the journal manuscripts and note what you have omitted from those. You may have one publishable manuscript or more, but you probably will have material that is not publishable.

3. Write a complementary section on auxiliary studies or supplemental data collected that are not included in the journal manuscripts. This portion of the thesis may appear in the form of a manuscript you do not expect to publish, as a report or series of reports, or as appendices. The form depends on what remains to be presented.
4. If appropriate and especially if the thesis includes more than one manuscript, write comprehensive conclusions to your entire study. These conclusions will be commentary on the extent to which you have accomplished your overall objectives and are satisfied the initial hypothesis relative to all the journal manuscripts. They may contain suggestions for further research and suggested applications for your findings. Theses will differ a great deal in how extensive the conclusion section should be. With the discussion and conclusions in other sections, some theses may not benefit from additional, separate conclusions.
5. Rather than a complete bibliography at the end of the thesis, place references or literature cited at the end of each chapter. At the end of the literature review chapter, you will have a list of all citations contained therein. Literature with each journal manuscript will be presented with the respective chapters in the style for the designated journal. This technique requires duplication of citations from the literature review, but it allows for review-ready copy for the manuscript. Similarly, numbering of tables and figures can be by chapter rather than sequentially throughout the thesis.

6.4.2.2 Doctoral Dissertation Incorporating Journal Manuscripts

The doctoral candidate must do all that the master's student has done and more because more original research and creative ideas are expected. The doctoral dissertation is likely to be made up of more than one journal manuscript and to contain additional supplementary materials. If the philosophic requirements for your degree are to be met, you may need to present a more extensive conclusion with commentary on scientific theory and philosophy that could not be published in journal articles. In addition to the same basic suggestions proposed for the master's thesis, I recommend the following for the doctoral dissertation:

1. Even after you have written two or more journal manuscripts, you will have a great deal of supplementary material left over. You may need to consider presenting those data in a chapter as well as in appendices.
2. You will review the literature more extensively and include ideas from related published works that may not have direct reference to your own objectives but do support the scientific principles behind your objectives and discussion.
3. As with the review of literature, the conclusions section to your dissertation should treat your subject more intensively and extensively than would the master's thesis. Discussion and conclusions will demonstrate an ability to think creatively and to integrate scientific ideas from the literature with your original research.

In other words, this doctoral thesis is a *dissertation*—that is, a lengthy treatise dealing with a subject from several perspectives that can direct your own scientific thinking and stimulate that of others in order to make a significant contribution to the scientific community. It is a document that helps to demonstrate your qualifications for the doctor of philosophy degree.

Caution. If you publish articles that you intend to include in your thesis before the document is complete, you may have to transfer copyright privileges to the publisher. Be sure to reach an agreement with that publisher to give you the right to publish the same material in your dissertation.

6.4.3 Other Formats

Unique studies may require other formats for the thesis. If you have another idea for putting the document together, consult your advisor and committee for their opinions. For example, a thesis or dissertation might be produced with the inclusion of journal manuscripts along with the original proposal. The proposal might be an initial chapter and might contain the comprehensive literature review. Or an introduction and literature review might be a separate section coming before the proposal section. These sections would be followed by the journal manuscripts and whatever complementary chapters, conclusions, and appendices were necessary. Except for the proposal and possibly the literature review, the outline for such a thesis would be the same as that for the thesis containing the journal manuscript.

One concern with this form for the thesis is that the proposal may need to be modified, but not actually rewritten, as the research progresses. Almost any extensive graduate study must evolve from an original plan, but new discoveries may be made or new methods discovered that require you to deviate from the original proposal, which some call a preproposal. Because this proposal is needed to establish the course of study, changes made along the way need not discredit the original plan or create a need for altering it. A record of the entire graduate program can be seen in the thesis that begins with a proposal, is carried through reports on the research, and ends with a discussion of any change from the original plan along with the successes and failures and their significance.

Good background information on scientific theses is in Stock (1985), Smith (1998), and O'Connor (1991). Bolker (1998) and Peters (1997) have practical suggestions for getting the thesis written. In Goldbort (2006), there is a chapter titled "Scientific Dissertations." Foss and Waters' (2007) book, *Destination Dissertation*, focuses primarily on social sciences, but it does have some valuable suggestions for any discipline, especially on writing and editing the dissertation and on sorting or "coding" the literature. You might enjoy reading Fitzpatrick et al. (1998). This book was written by three people who had just finished their dissertations. It has a light flavor and good humor that make it easy to read, but it also deals with the serious issues.

Caution. Be sure that you have the approval of your advisor, committee, and graduate school before you decide on the form for your thesis. The ideas expressed here are not necessarily new, and certainly not revolutionary, but many advisors or graduate schools have rigid criteria that may not be met with these suggestions.

6.5 THE THESIS DEFENSE

Most science departments require an oral exam or a defense of your thesis, especially at the doctoral level. Although students worry and fret, this event is typically not confrontational and can even be enjoyable if you have done a good job with your research and your writing and have timed the situation well. Timing is important. Be sure you get copies of your thesis to committee members 2 or 3 weeks before the defense. Attitudes developed by being rushed to read the document can be detrimental to your academic health during the defense. You need adequate time to talk with committee members before the group defense to discuss particular issues that relate to their individual observations and that may arise during the defense.

When your major advisor and you decide that the thesis is ready, distribute copies, and your advisor or you will schedule the defense. The time should be as convenient as possible for everyone concerned. Sometimes it is difficult to get all committee members together at the same time, especially if you wait until the last minute to schedule. Defenses are often open to the public, and your graduate school may require that the time and topic be announced publicly. If possible, schedule the meeting in a comfortable room and arrange chairs so that you are simply one of the group and the arrangement is not a physical one of "you against them." A round table arrangement is good.

Before the final defense, you may have made a presentation on your research to your entire department with all your committee members present. If not, you may want to make a short presentation as you begin the defense to introduce the main points and findings of your study. Ask your advisor whether such a presentation is appropriate. If you do one, ensure that all equipment is working and the physical arrangement allows everyone to comfortably view your visual aids. Do a good job presenting. Although much of the perceived value of your study should rest with the written thesis, human beings are influenced by the skills of an effective presenter. After the presentation, you will simply join the group for their questions and discussion.

Every committee is different in its approach to the defense, but typically the goals are similar. Most are not there to harass you or to ask questions they do not expect you to be able to answer. Although they are evaluating your knowledge and the strength of your work, typically if you have succeeded to this point, you can pass this defense. Be conscious of the questions in your audience's minds. As they read your thesis, they are asking such questions as "Is the problem well defined here?" "Is the research design effective?" "Is the background literature

accurate and appropriate?" "Are the results clear with data well presented and interpreted?" "Is the discussion meaningful?" "How thorough was this study?" "Is the thesis well written and easy to follow?" "Are the parts organized and written appropriately (title, abstract, methods, appendices, etc.)?" If they are satisfied with positive answers to these questions, the oral defense will be easy.

The questions that committee members ask during the defense will depend on their reactions in reading the thesis and in having worked with you through your program. Of course, the questions will differ for every research project, but the specific questions often fall under these general categories: What do you believe are the strong and weak points in your study? What was the most important question that you answered in pursuing this research? What have you learned? How will you use what you have learned? Do you see any biases or unanswered questions relative to your objectives? How does this work contribute to the discipline? What other work is currently being done in this area? If you had an opportunity to pursue this research further, what direction would you take with it?

In addition to questions about your project and the science itself, you may be asked about the form and style of the thesis, about findings in the literature, why you used certain methods, why you used tables or certain kinds of figures, why you chose certain statistical analyses, or where you plan to publish this information and why. Some final oral exams consist not only of a defense of the thesis but also of questions that any master's or doctoral degree recipient should be able to answer about the discipline. If this kind of exam is given, be sure you are familiar with current events in your discipline as well as some history and the basic principles of the science behind your work. You can find out what kind of exam or defense you will have by talking with your advisor and other committee members and with graduate students who have experienced the event recently in your department. Peters (1997) has good suggestions in Chapter 19 about how to prepare for and perform during a defense.

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Chapter 7

Publishing in Scientific Journals

In science the credit goes to the man who convinces the world, not to the man to whom the idea first occurs.

—Sir William Osler

Almost all landmark publications, such as that of Watson and Crick on the structure of DNA, are the result of numerous reports written before putting the final piece into a scientific puzzle. That final piece often gets the publicity, but without the aid of past discoveries, the breakthrough would be impossible. Perhaps every scientist dreams of making a groundbreaking discovery in research and of publishing an article that will be considered a classic of the discipline, but every good scientist must also depend on the work of previous thinkers and researchers. As Sir Isaac Newton declared, "If I have seen further, it is by standing on the shoulders of giants." Rather than that landmark publication, most likely your own publication will be a stepping stone in the progress of science.

Scientists publish information in a great many forms. Books for students and lay audiences, chapters in books, magazine articles for the public, reviews, letters and short notes for journals, and numerous other forms feed the network of scientific communication. But perhaps the most common, most influential, and widely distributed form is the journal article. To provide the fundamentals and some details in publication, I concentrate on the typical journal manuscript in this chapter. Other avenues for communicating with scientists working in other careers or with nonscientists are discussed in Chapter 19.

Technology may be changing the forms for the communication, but however it is disseminated, the primary report from original research in a journal article remains essential for information transfer among scientists. Contributions to the journal literature can go far in building your professional reputation. To acquire the right reputation, not only must your discovery be new and valuable for others to read and use in their research but also the manuscript must be a well-written, clear disclosure of information.

7.1 PLANNING AND WRITING THE PAPER

When data are collected and analyzed and the results of your research are ready to publish, you have several decisions to make. When can you finish

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the writing? Will you have coauthors? Who will give you helpful reviews? To which journal will you submit your manuscript? How soon will it be published? What is the possibility for acceptance? How do you deal with editors? Most of these questions do not have simple answers, but some general ideas may help you to follow the process of writing for journal publication. Peat et al. (2002) provide more detailed answers. Their book primarily concerns journal publication for the medical professions, but most of the ideas can be applied to almost any scientific journal.

Before you write the paper, determine who your coauthors will be and your position with them. Read about giving credit in *On Being a Scientist* (Committee on Science, Engineering, and Public Policy, 1995), and check what your style manual has to say about authorship, the order of authors, and multiple authors and their ethical responsibilities. Each author should have made a real contribution to the research, should be responsible for content of the manuscript, and should be involved in writing and reviewing the paper. Also, talk with your advisor and discuss with any coauthors the order in which the names will occur on the paper.

You and your coauthors should select the journal to which you will submit your manuscript before you write or by the time you have written a rough draft. The best journal for one manuscript is not best for another. The subject of your particular manuscript may be better for a local, regional, national, or international audience. Follow journal guidelines or scan article titles to be sure you know what subjects are accepted by the journal. Read a few articles closely and examine quality, style, and subject matter. Determine whether the paper will be refereed and the name of the publisher. Papers that are refereed, or reviewed, are not only better because of this process but also more highly respected by other professionals. You want your publication to be in good company; the reputation of the publisher and journal reflects on your own. Your own society probably publishes quality journals, and many other publishers are equally reputable.

After you have decided where to submit your manuscript, acquire the "Instructions to Authors" or similar guidelines furnished by the journal. You should be able to find these instructions on the publisher's website. Many journals publish instructions directly in the journals. After you have studied the journal and its guidelines, write your first draft with the audience and the publication style of the specific journal in mind. If you later decide to submit to a different journal, again study the publication guidelines and revise your paper to its style and audience.

In selecting the journal to which to submit your work, you should consider circulation and the probable interval between submission and publication. Some journals provide information on the time from the receipt of the initial manuscript to its publication. This period can be measured at least in months, and often publication is well over 1 year or more from the time the editor receives the manuscript. Some publications are known for a rapid turnaround

time, but they may or may not be refereed or known for discrimination in the manuscripts they accept.

Write the paper as you do the research. Now is the time to make good use of O'Connor (1991) or follow the recipe of Day and Gastel (2006) or Gustavii (2008) for writing for journal publication. Get background literature together, and you may want to write a working title and a rough draft of the introduction before your results are available. Write a preliminary abstract without including results. This abstract will help to keep the justification, objectives, and main point in your mind when you begin to consider the results. Write the materials and methods section when you set up the experiment. Then, when results are ready, you can write the results and discussion section(s) and the conclusion and revise the introduction and title. Finally, revise the abstract by inserting results and a concluding remark and paring it down to the required size. Remember, every section of the paper will have to be revised several times before it is ready for publication. If you are a graduate student, you may be producing a chapter for your thesis as well as a manuscript for submission to a journal. Make whatever adjustments you need for the two documents. See Chapter 6 on writing a thesis.

7.2 JOURNAL MANUSCRIPT CONTENTS

Now your outline, as discussed in Chapter 3, can be put together or revised. The contents for your paper can be arranged in the following order and by the standards of almost any research article published in a scientific journal. There are exceptions; check your journal.

The **introduction** should be a brief but clear statement on the topic and objectives of your research. It should serve to call attention to and clarify or define the specific hypothesis or question that you pursued in your study. It should show where your work fits with the literature that provides background and most clearly supports a rationale for the study relative to its importance, but do not make a literature review of your introduction. Simply and briefly justify your work. Most important, make clear the specific objectives you set out to pursue with your research project.

The **materials and methods** section will be a recipe revealing how you acquired and analyzed your data. Organization here is usually easy with step-by-step procedures kept in the same order as the objectives were listed in the introduction. You can preface these procedures with a listing of materials used, conditions present, and the design of the project, or introduce these as you reach the steps that make use of them. In addition to needing details of the materials and methods used, the audience will also be asking two major questions: Is this researcher's work credible? and Can I replicate the same methods? To answer these questions, you must provide complete information on ingredients, actions, conditions, experimental design, replications, repetitions, and statistical analysis. Ask yourself: Could another scientist follow my words in this

part of my paper and perform the same experiment with the same results? A well-written methods section will support a positive answer.

Results should not keep a reader in suspense. Make clear immediately the extent to which you have proved or disproved your hypothesis, and then carry the reader from one display of data to another with logical development showing how your findings satisfy your objectives. Results may be presented in the same order as the objectives and the experimental procedures. Data are often presented in tables or figures, and the text will simply serve to tie the data to your objectives or to call attention to main points in the data display.

The most critical contents of results in many papers are the figures and tables. These establish evidence for the statements you make in the text of both your results and your discussion. It is essential that the display of data be accurate and clear. See information on tables and figures in Chapter 11. Both Gustavii (2008) and Briscoe (1996) offer more complete information on tables and figures, with examples of both good and poor construction. Briscoe includes examples of various kinds of figures, such as drawings, photographs, bar and line graphs, and molecular graphs. Moreover, it is imperative that you follow your journal guidelines for the stylistic specifications for tables and figures, especially relative to size and orientation. As with all elements of publishing style, follow instructions from these guidelines or the journal editor.

Discussion is sometimes interwoven with results, or it can be in a separate section. Follow whichever arrangement your journal uses. Discussion provides meaning or an interpretation of the results and shows relationships with other research reported in the literature. Summarizing statements will tie together outcomes as depicted by the various data sets. As with results, strongly focus the discussion on your objectives. Discussion should present the overall significance of your work and help direct the thinking of your audience, but once you have made a statement on what your data mean, do not go too far afield with speculation. Show how your results fit into or compare with those from similar studies reported in the literature, and leave to the minds of your readers most of the speculation. Let them form their own opinions. In addition to the valid experimental design that you present in your methods, your results and your discussion will establish your credibility.

Finally, be sure to make concluding statements at the end of your discussion or in a section called **conclusions**. Briefly reiterate your objectives, and provide a general statement on the extent to which you have accomplished them. Be sure you do not simply restate the results here, but draw together outcomes of your objectives and refer to data that support the conclusions. Enumerate these conclusions succinctly. They may be the points that stay longest in the reader's mind.

7.3 AFTER THE PAPER IS WRITTEN

After you have written and rewritten your paper and every coauthor has reviewed and revised it, you will reach a point where you cannot see how to

make the communication any better. It is time then to ask for reviews from your own peers or professors. Most institutions or companies you work with and certainly the department in which you are doing graduate work will suggest or require that you obtain in-house reviews before submitting the paper to a journal. Many will require approval before submission and publication. Know the requirements of your department or employer before you submit a paper to a journal.

Before it is sent to the journal, choose at least two or three in-house reviewers carefully. One may be someone who is familiar with your work. That one may recognize some important omission that you had assumed was obvious and failed to include in the text. Choose another reviewer who knows nothing or little about what you have been working on but has expertise in similar scientific matters. This reviewer can best give an objective look at both the science and the communication. You may wish to ask for a review from a scientist working at another institution or agency. Get at least a partial review from a statistician. Also, an editor or other reviewer who may not be a scientist can often improve readability and organization.

Finally, with these reviews complete and with further revisions of the paper finished, you are ready to submit your paper to the journal. Read again the "Instructions to Authors" or other information that is available with the journal or from the publisher. That information will probably tell you about page charges and submission requirements for page size, line spacing and numbering, and other matters of form and style. Check all details carefully before submitting the manuscript. It is easy to forget an important point. The editor may want you to send the manuscript electronically or send three or more hard copies for reviews. Submit neat, clear copies of the text, figures, and photographs. Clear all issues for submitting the manuscript by reading guidelines or talking with the editor. After submitting the manuscript, carefully store your copy and all your data and analyses. You may need those data in the future even if you believe you are finished with them entirely.

Above all, be sure your paper is ready to be submitted. One scientist who reviews regularly told me that the mistake made most often is submission of a paper that is a good rough draft but definitely not ready for journal review. He emphasized that the role of reviewers is not to rewrite or to revise the paper for you, and they are not pleased to waste time reviewing a poorly written manuscript.

Submit your paper to only one journal. Instructions for submission usually indicate that the paper will be considered only if no other journal is concurrently considering it. You may think your chances for acceptance are better if you try two or three journals, but it is unethical to expect the publishing staff and reviewers to spend time and money reviewing and editing your paper only to have it published by another journal. Wait for a rejection from the first journal or ask that your paper be released by the first editor before you submit to a second. Once you submit it, the paper is considered the property of the publisher until it is released. If you believe the first publisher is taking too long or asking

for revisions that you cannot make, ask that the paper be released and send it to another journal, but until then, be patient.

With copy submitted, include a cover letter requesting that the manuscript be considered for publication in that journal and giving the editor a phone number and an e-mail address as well as the mailing address where you can be reached. If your paper has any unique characteristics, give the editor any information needed to understand. However, make the letter as simple as possible with only the necessary information. Do not try to convince the editor that it is a wonderful paper. To indicate the suitability of the manuscript for the journal, in your letter you can note briefly which section of the journal it is best suited for or describe the kind of research findings you are reporting. After you receive confirmation that the paper is received, be patient. It takes a while for reviews and editor consideration. If you receive no word in 2 or 3 months, call the editor and ask about its status.

Acceptance of your paper depends on not only how good the research is and how well you write but also the suitability of the subject and the acceptance rate of the journal. Acceptance can be influenced by the number of submissions to the journal or the subject matter that the journal prefers to publish. The rate of acceptance may range between 10 and 65% of those received, but some prestigious journals may accept fewer than 10%, and for others the rate may be more than 65%. Whatever the acceptance rate, it is best to be sure the journal has a review process and is reputable in your discipline.

7.4 THE EDITING AND REVIEWING PROCESS

Editors are human beings with all kinds of personalities; they are sometimes amiable and sometimes surly. Deal with them the way you do other humans; most will appreciate direct, open, and professional communication with you and will work with you and reviewers to produce the best possible paper. Do not be afraid to discuss and even reject editorial changes that could result in a focus or meaning in your paper that you do not want, but do so professionally and listen closely to any criticism. The editors probably have more experience in both writing and publishing than you have. However, what is published appears not under the editor's or reviewer's name but under yours.

Peat et al. (2002) and Day and Gastel (2006) provide good information on the publishing process as well as on reviewers and editors. However, editorial staffs may be organized in different ways. The journal's "Instructions to Authors" or your style manual may outline the review and editing process used. Editors usually log in a manuscript when it is received. If the format and the subject matter are appropriate for the particular journal, that editor will probably then seek other reviewers or send it to an associate editor who will review and seek reviews and communicate with you. Review processes also differ, but at least two other persons will likely review your paper. On the basis of the opinions of reviewers and the editor, your paper will be accepted, accepted for reconsideration with revisions, or rejected.

Seldom will a paper be accepted with no revisions suggested. If this rare event does happen in your life, you will simply be notified that your paper is accepted and going to press. More likely, your paper will be tentatively accepted, but revisions will be required. In this situation, your editor will evaluate the reviews, form an opinion, and send recommendations for revisions to you. You certainly may disagree with reviewers, but you should justify in writing to the editor any failure to address a recommendation. Be open with your own opinion, but remember that anger is a recipe for disaster in almost any situation. Reviewers may be wrong, but reviewing is not easy and someday you will probably have to play that role. See Chapter 9 for more on reviewing and revising. Make the most of the revisions suggested and send the new copy back to that editor. You may receive a second set of recommendations and have to revise yet again. But when satisfied the paper is ready for publication, the editor will notify you and put the paper into the publication process.

If the reviewers and your editor believe the paper should be rejected, it will be returned to you. The editor should provide an explanation for why the paper has been rejected and may recommend major revision that would make the paper acceptable. Do not despair when you get that rejection (Figure 7.1); most

FIGURE 7.1 Don't despair when you get that rejection.

of us have experienced the same. Handle any disagreement with respect and amiability. You can certainly discuss the quality or subject matter in the paper with your editor, but be professional in disagreeing with any recommendation or rejection. If you believe your paper is worthy of publication, revise it again and resubmit it or try another journal.

The following reasons overlap, but one or more of them may explain why your manuscript was unacceptable for publication:

1. The research was inappropriate for that journal or was poorly planned and executed.
2. The manuscript was poorly written or did not follow the style of the journal.
3. The research results are inconclusive; you have insufficient data or erroneous interpretations.
4. Interpretation is missing or discussion is unwarranted.
5. The research is trivial or incomplete, or the information is not new or is repetitious of previous publications.
6. You have too much material; the paper is too long, wordy, or padded with unimportant data or discussion.

The publication process for professional journals is not perfect. Poor research and poor writing are sometimes published or good research and writing rejected by reputable publishers. However, the process may be as effective as human error will allow. If you will familiarize yourself with what goes on during consideration of your paper, you will be less frustrated with editors and reviewers and with the time required to publish. Reviewers and editors can be very helpful, and your paper will usually be better if you take their advice. If you do not agree with a direct suggestion, you still need to consider it and determine whether you should make some adjustment in the text. Reviewers, who are usually not professional writers and editors, often know something is wrong but cannot identify the exact problem. Take their criticism as an indication that the writing at that point is not clear. Most editors and reviewers are trying to make your paper better, not destroy it, with their suggestions.

Once your paper is accepted, you will have a few final chores to do before you see it published. If you submit it electronically, be sure that version and any hard copy submitted are exactly the same. Before the final copy is published, you will probably be sent a copy called galley, or galley proof, to be proofread in the form set up for printing. Proofread this galley with great care and have at least one other person proof it. You are responsible for any errors in the text. In addition, you may be asked to sign a sheet to give copyright privileges to the publisher. This signature will transfer your copyright, or the publisher may simply be asking for permission to print and reprint your work. Read the fine print to determine the extent to which you retain the copyright privileges. A final chore may be payment of publication charges. Authors are usually charged a fee per page of publication. Your editor can tell you what these charges are.

Always consult a recent issue of the journal to which you submit your work and read the "Instructions to Authors" or other information about that publisher's process. The major style manuals offer a great deal of information on the responsibilities of authors, editors, and reviewers as well as information on the publishing process. The steps and actions I have described are generalized, and they will continue to change as publishers update their technology to suit their needs and make more changes with electronic publication. You may see your publication in an electronic format rather than a bound journal. Lessen your frustrations by keeping up with what is going on. But keep in mind that the ease in electronic dissemination of information removes none of the responsibility from an author for submitting a concise, well-written report.

As a final caution, do not write your first scientific paper for publication without consulting the journal's notes and a style sheet or manual that a particular publisher uses. If you are a graduate student, your advisor or other faculty who have published repeatedly can answer many of your questions. Then, consult the style sheet or a manual for your discipline and journal guidelines. Your editor should be able to answer any questions that these sources do not.

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Chapter 8

Style and Accuracy in the Final Draft

The simplest rule of thumb for the author and illustrator should be: Follow what you see in print.

—Council of Biology Editors

Attention in early drafts of a paper should focus on organization and content, but, as you revise, you should also be conscious of format and details that are essential to the final draft. Before the paper goes to reviewers, check carefully for accuracy and form in style and documentation. The final chore is to proofread carefully so that sentence structure and punctuation make the text read smoothly and that reviewers are not distracted by errors in style and grammar.

8.1 STYLE

In scientific writing when we refer to style, we are usually not referring to the effect that your personal creativity or literary training has on your writing. Rather, we are interested in clarity and consistency in the use of words and other symbols. Style in this sense particularly refers to the typographical accuracy, appearance, and details in the form that your work takes. This **technical style** includes what is acceptable or unacceptable to editors in organization, font, capitalization, punctuation, indentions and spacing, abbreviations, citations and bibliographies, headings, footnotes, and any other conventions in the presentation of the entire work. Style is the way publishers or editors want to use acceptable conventions to print text to give a physical as well as verbal appearance to their publications and to your paper. The way words are physically arranged, capitalized, and punctuated can add clarity to the communication, but unfortunately, editors and publishers do not entirely agree on standards for these details.

Despite somewhat successful efforts by the Council of Science Editors (formerly the Council of Biology Editors) and others, standards for style are still inconsistent in the scientific community. Some traditional points of style have changed throughout the years, just as acceptable grammatical usage has changed. For example, you may have learned that numbers up to 10 should

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be spelled out in words and others written as numerals. Many journals use all numerals except in specific instances, such as at the beginning of a sentence. Almost all publishers of scientific journals follow similar organizational patterns, but the headings will differ. What one calls Methods, another may call Experimental Procedures; and where one may want you to combine the Results and Discussion sections, another may separate the two. Notice also the position and type styles used in headings and small details such as abbreviations and punctuation. Study carefully the style of the publishers to which you intend to submit your work and adhere to the style you see in their printed journals. Editors or reviewers are much more likely to read your paper with a positive attitude if you have been attentive to their preferred style.

Although styles differ widely, some efforts toward uniformity have been made in recent years. More than 30 years ago, editors meeting in Vancouver made special efforts to bring about uniformity in publications. Also, the international system for units of measure is an important step forward. The Council of Science Editors (CSE) produced their 2006 edition of *Scientific Style and Format* with a goal of providing uniformity in technical style for the sciences. This style manual includes details in style not only for the biological and medical sciences but also for chemical, astronomical, and earth sciences. Other style manuals, such as the *AMA Manual of Style* (Iverson et al., 2007) and *The ACS Style Guide* (Coghill and Garson, 2006), provide information on technical style as well as on issues such as planning, writing, and submitting the paper for publication, but they concentrate more on their particular disciplines. These efforts have made progress in consistency with style across the sciences, but many editors and publishers still have their own formats and styles. Most large professional societies and agencies print more limited style sheets or manuals for their contributors. A list of these is provided in Scientific Style and Format (CSE, 2006). In addition, each scientific journal publishes an abbreviated style sheet called "Instructions to Authors," "Suggestions to Contributors," or a similar title.

Decide where you wish to publish early in your writing and carefully follow the style sheet for that publisher. Failure to do so may mean that an editor will reject the manuscript even before he or she sends it to review. The masthead near the front of the journal usually contains documentation concerning the publication and information about such things as subscription rates and publication charges as well as where to find information on the journal style.

8.2 STYLES IN HEADINGS

Manuscripts for journal articles, chapters in books and theses, proposals, or other documents or publications often need to be subdivided into sections. Headings provide transitional guideposts to link these divisions. Check a style sheet or an example of a publication to determine spacing as well as heading

and subheading patterns, or make your own style neat, consistent, and attractive. Most important is to be consistent in print style, size, and position for headings that are parallel or of equal importance. Headings are usually designated as primary, secondary, and tertiary heads or first-, second-, and third-level headings. You will seldom, if ever, need fourth- or fifth-level headings. Notice the symbolic emphasis given to the various headings below, and see Chapter 14 for more information on symbolic language. Font, positioning, spacing, boldface, underlining, italics, capitalization, or other symbolic dimensions can be manipulated to provide more or less emphasis to a heading. I have attempted to arrange the following examples relative to their importance, but various forms of enhancement can change this order.

Sample headings:

1. Center
   A. Use total capitals

RESULTS AND DISCUSSION
or
RESULTS and DISCUSSION

   B. Underline and/or boldface

<u>Results and Discussion</u>

   C. With no added enhancement

Nitrogen Study, 2010

2. Left margin
   A. Above line, underlined, italic, or boldface

Nitrogen Study, 2010
   Text begins here …
   B. Above line, not embellished

Nitrogen Study, 2010
   Text begins here …
   C. On line, italic, or boldface

Nitrogen Study, 2010. Text begins here …
   D. On line, paragraph indention, underlined, italic, or boldface
      <u>Nitrogen Study, 2010</u>. Text begins here …
   E. Pattern C or D with no embellishment

8.3 ACCURACY AND STYLE IN DOCUMENTATION

A most obvious point at which styles differ widely among journals is in their techniques for handling the references. Both the form for citing the reference in the text and the form used in the bibliography may differ from one journal to the next. A *bibliography* is a list of works related to a text. These works may or may not be literature (i.e., published) and may or may not be cited in the text. Even the heading for the bibliography differs between journals.

Most bibliographies are called “Literature Cited” or “References.” Both are bibliographies limited to works cited in a text. If authors add any additional references not cited in the text, these can be titled “Related Literature” or “Suggested Reading,” but for journal articles, such citations are usually not included. *Literature cited* usually refers only to published literature that is cited in the text. *References* may or may not be published works (e.g., personal communications or in-house documents might be included) but are cited in the text.

The most essential criteria for documentation are that it be accurate, complete, and up-to-date so that your readers can readily find any source of information that you have cited. Whatever the style of the publisher, the reference should include what is available of the following: **author**, **date**, **title** (some journals omit title), and **source** (publisher and place of publication or journal name, volume number, and page). Every citation must be documented clearly and completely according to the style of your publisher. When a style for citations in the text and in the bibliographic list is not dictated by your publisher, at least be consistent, complete, and accurate. If you give erroneous details about a source, you will mislead and frustrate another researcher and degrade your own credibility.

Details in style differ in the reference lists for the various journals. Punctuation, capitalization, use of first names or initials, as well as dates and their placement—it is amazing how many ways can be found to alter styles. Styles include the alphabet–number system, the name–year system, and the citation sequence system. Because of the ease in adding or deleting citations, I suggest that you use the name–year system as you write the paper, even if you have to change to a different system when you write final drafts. The following are samples of some basic styles for references. Notice differences in punctuation, order, and other details. Look to the journal to which you are submitting your work; its style is likely to differ from any of my examples. You may be able to use software such as Endnotes, Refworks, or Zotera to set all your citations in one of these styles and to change all automatically from one style to another. The important point is to be sure the list in the copy you submit for publication is in the style of your publisher.

Three systems for textual citations and bibliographies:

1. **Alphabet–number system**

   Examples in the text

   a. In 2008, Bilbrey and Rawls (2) developed a technique for ….
   b. With the mathematical model (2), we could project ….
   c. Several theories have been proposed for measuring soil water potential (2, 4, 7, 13, 21).

   Advantages and disadvantages

   This system provides little interruption to the text, is less costly to the publisher than is the name–year system, and can feature the name of the author(s) or a date in the text as in example *a*. However, the system does

not always give immediate identification by name and year. If writers add or delete references, they must carefully renumber citations throughout the text as well as in the bibliography. The list of references is alphabetized and numbered to correspond with the citations in the text.

Sample bibliography for the alphabet–number system

Literature Cited*

1. Adcock, R. L. 1998. Moisture stress on soybean pod development. Crop J. 95: 345–347.
2. Bilbrey, J. C., and R. M. Rawls. 2008. Measuring soil water potential in a Sharkey clay. Gen. Soil Sci. J. 13: 121–124.
3. Green, C. R., A. C. Dobbins, V. C. Martin, and W. R. Amity. 2010. Response of grapes (*Vitis lubrusca*) to drip irrigation. [Internet] HortReport 59: 13–14. (Online at http://www.fruitprod.net/waterneeds.html. Accessed 11 June 2011.)

2. Name–year system

Examples in text

a. Bilbrey and Rawls (2008) developed a technique for ….

b. By using a mathematical model (Bilbrey and Rawls, 2008), we could project ….

c. Several theories have been proposed for measuring soil water potential (Adcock, 1998; Bilbrey and Rawls, 2008ab; Dobbins, 1999; Ferguson and Fox, 1999; Fox, 1991; Lennon et al., 2005; Watson et al., 1995). These theories allow for ….

Advantages and disadvantages

With this system, the writer can add or delete references easily. Some immediate identification of the reference is apparent. However, several such citations in a row can distract, and publishing cost is greater than that for the number system. The list of references is always alphabetized.

Sample bibliography for the name–year system

References*

Adcock, R. L. Moisture stress on soybean pod development. Crop J. 95: 342–345; 1998.

Bilbrey, J. C.; Rawls, R. M. Measuring soil water potential in a Sharkey clay. Gen. Soil Sci. J. 13: 117–121; 2008a.

Bilbrey, J. C.; Rawls, R. M. Drip irrigation for grapes. HortReport 78: 14–15; 2008b.

3. Citation sequence system

Textual citations and bibliographic list are numbered in the order in which they appear in the text and so the list is not alphabetical. Numbers in the text are often superscripts or may be on the line in parentheses.

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*All references are fictitious publications.

Example in the text

In 1995, Fox[1] developed a technique to measure soil water potential. Bilbrey and Rawls[2] modified that technique in 2008 to the form used today[3,4,5].

Advantages and disadvantages

This system is less expensive for the publisher than the name–year system and is simple for printing short papers with short lists of references. A specific reference can be difficult to locate if the list is long unless you first refer to the number in the text. Making corrections and insertions in early drafts of a paper using this technique can be difficult. The list is not alphabetized but is numbered and references are listed in the order of occurrence in the text.

Sample bibliography for the citation sequence system

References*

1. Fox, R. T. (1995) Agric. Bull. 102, 47–49.
2. Bilbrey, J. C. and Rawls, R. M. (2008) HortReport 32, 17–21.
3. Lennon, T. R., Elzie, M. S., and Cola, R. C. (2004) Crop J. 79, 173–177.

These forms are all acceptable in some publications, but none may be appropriate to the editor and publisher to which you submit your work. Always carefully follow the style of the publisher for which you are writing.

8.3.1 Documentation of Electronic Sources

With increasingly more information being acquired from nonprint sources, clear citation of those sources is equally as important as reference to printed material. The important point in documenting material is that a reader can find the same source with the same information. However, standards for storing and documenting electronic sources are not stable. Not all material online is archived as is printed text, and it can be changed or even removed from the network.

The same basic information as is used with printed sources should be included in the documentation of the electronic source: **author, title, source** (publisher or journal), and **date of publication and the last update**. In addition, include the physical description or notes the reader may need for acquiring and viewing or listening. For an electronic source from the Internet, write "[Internet]" after the title and list the **URL** (uniform resource locator) or access address and **the date you accessed it**. As with any element of style that you question, check with your own editor to be sure you use the preferred form. Citations for the Internet material will usually be arranged as follows (note that these are fictitious sources):

Suggested format: Author Name, Title [Internet], City and State; Location, Date [Date updated], Date accessed, Available from http://www e-address of source.

Example: Kurtz, JE. Earthworm activity in petroleum-contaminated soils [Internet], Tulsa, OK. Tulsa University Department of Soils: 3 March 2007. Updated 10 October 2011. Accessed 1 January 2012. Available from http://www.TU.edu.worms.

Printed sources remain the same; changes occur only by producing a new edition that remains the same with any changes made from earlier editions. For this reason, the edition is numbered and the date of publication is important. However, because information can be changed or deleted from the Internet, you should provide the date when it was last updated as well as the date when you verified that it was there. Problems with documentation of electronic sources are far from solved. Information is available on documentation of electronic sources in the recent style manuals as well as in Hofmann (2010). You can also find information on citing electronic documents on the Internet. More simply, when you need to use such citations, as with printed sources, check to see how your journal or editor lists them. Be alert to new information on electronic documentation.

8.3.2 Other Style Issues

Headings and documentation are just two prominent areas in which styles differ markedly between publishers. Use of abbreviations, spacing, footnotes, and other inclusions will differ. If decisions on style rest with you, certainly you need to be conscious of the communicative value of how a page looks to a reader as well as what the words say. Most important, be sure that you have proofread your final draft so that you do not burden the reader with distracting errors. As C. C. Colton says, "That writer does the most who gives his reader the *most* knowledge and takes from him the *least* time."

8.4 PROOFREADING

Probably nothing blows smoke in the eyes of communication more quickly than the small mechanical error. Do not try to make early drafts of a paper perfect, but when you reach the final stages before sending a manuscript to your reviewers, then proofread as though the entire acceptance of the paper were at stake, and it may well be. Readers come to your work from outside. They may pay attention to content until they stumble across the misspelled word, the transposed letters, or a word or phrase out of place. Then the mind jumps to that small point and can entirely leave the content. The reader's mind is ticking with "That's not right. Isn't it *i* before *e*? Shouldn't that be a capital? I never could spell that word either …" and so on until what you were saying gets lost in something such as two small letters transposed. Often, people let important decisions about your reputation hang on the grammar and mechanics in your writing. A professor once pushed a paper in front of me and said something to the effect of "Look there—A misspelled word in the first line. Don't they

teach spelling anymore? Such people shouldn't be in graduate school." Before such readers finish with reading, they may believe you are a careless, uneducated individual, and they will hesitate to hire you or publish your work. Learn to proofread.

Proofreading is not editing or reviewing. The proofreader is looking for the mechanical or grammatical error and only indirectly at the content. Proofreading is not like any other kind of reading. There is scanning, there is careful reading, there is studying texts for content, and there is speed reading. But none of those are proofreading. Keep in mind that proofreading your own paper is most difficult. You will easily read over errors because you are too familiar with the work and you may not distinguish between what it does say and what it should say. For important papers, always ask someone else to proofread the final version.

If I am asked to proofread a paper I am not familiar with, I usually read it at least two or three times. First, I read through the paper so that the basic content will not distract me the second time through. During the first reading, I may catch several errors that I check lightly. Then I read the text word by word, phrase by phrase, and scrutinize the choice of words, the order of the phrases. As I find errors, I mark them lightly. If I have found very few errors, I may stop at that point. If I find several, I read for a third time. This time I read with the flow of the words, sentence by sentence, paragraph by paragraph, paying attention to sentence structure and yet again noting any error I missed in earlier readings. Then I go back and mark each error carefully with the appropriate proofreader's symbol.

With word processing, some proofreading can be done on the monitor and corrections can be made easily. Some people read from the screen more easily than others. I recommend that at least one reading be done from hard copy. The screen may not show exactly how the work will look on the printed page. Use the spell-check and grammar-check features in word processing, but do not trust them implicitly. They may miss real words that are used incorrectly, such as the substitution of *effect* for *affect* or *the* for *they*.

If you have trouble catching errors, read aloud, or have someone read slowly to you while you follow the copy. Have that second reader proof your final draft. Proofread and mark copy carefully. Table 8.1 contains some handy symbols to know. Others are listed in unabridged dictionaries or style manuals.

As you write your proposal, thesis, report, or paper for publication, you are most concerned with the research itself and how to report that research to an audience. You must think about the major issues—which data to use and how to organize and develop content for the greatest clarity. However, the small details may condemn good content in the final version. Adhering to a consistent publication style and proofreading carefully can certainly influence the acceptance or rejection of your manuscript.

TABLE 8.1 Common Proofreader's Marks

Correction	Marginal Symbol	Marked text	Corrected text
Delete		the ~~old~~ cat	the cat
Restore deletion	stet	the ~~old~~ cat	the old cat
Close up space		the o ld cat	the old cat
Insert	old	the cat	the old cat
Replace	old	the ~~big~~ cat	the old cat
Insert space	#	thecat	the cat
New paragraph	¶	¶Once upon a time	Once upon a time
Move to left		the dog	the dog
Move to right		the dog	the dog
Center	ctr	the dog	the dog
Transpose	tr	the on dog	on the dog
make lower case	lc	the ~~O~~ld dog	the old dog
Capitalize	Cap	jim burns	Jim Burns
Period		Go west	Go west.
Comma		Come Jim.	Come, Jim.
Apostrophe		Jims dog	Jim's dog
Superscript	2	3 m2	3 m^2
Subscript	2	H2O	H_2O

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Chapter 9

Reviewing and Revising

No one can make you feel inferior without your permission.

—Eleanor Roosevelt

We are the products of editing, rather than authorship.

—George Weld

For almost any craft or art form, the initial rough creation has to be reshaped, sanded, revised, polished, or fine-tuned, as do the draft and subsequent forms of a scientific paper. In other words, good scientific communication is not the product of an initial attempt by a talented writer but, rather, the end result of repeated reviewing and revising (Figure 9.1). As Zinsser (1998) says, "If you find that writing is hard, it's because it is hard." Tough revision is essential, and good reviews can be helpful in this process. Few people write well; many people can revise well.

Recognize that, before it is acceptable to your audience, a well-written paper will be reviewed and revised at least three or more times. A barrier to achieving a well-done final draft can be a failure to admit that you, like everyone else, need to revise more than once and need the opinions of others. I assure you that in addition to being reviewed and revised through three editions, every chapter of each edition of this book has had multiple reviews and revisions, and every one of them has been helpful. As a scientist, you will review and revise your own work, use reviews from others in revising your work, and serve as a reviewer for other authors. Before asking others to review a paper, review and revise it carefully yourself.

9.1 REVIEWING AND REVISING YOUR OWN PAPER

Learning to review and revise your own work requires an attitude of confidence but of objectivity and humility as well. To look at your work objectively is difficult, but with an open mind you can develop an ability to do so. After you have written your first draft, carry your reviews through at least three stages of revision before you expect someone else to work with the paper.

M. Davis, K.J. Davis, M.M. Dunagan: Scientific Papers and Presentations, Third edition.
DOI: http://dx.doi.org/10.1016/B978-0-12-384727-0.00009-4

FIGURE 9.1 Good communication has to be polished from an initial rough draft.

You will first review and revise the general content and internal organization to determine if you are emphasizing the main point of the paper and that the order is logical and content is easy for a reader to follow. Then, revise individual parts of the paper to support the main point in the introduction, methods, results, discussion, supporting literature, tables and figures, and conclusions. Do not worry about spelling and punctuation with these first two reviews, but in a final revision pay attention to clarity and details in style, diction, and mechanics. Try some of the following ideas.

Stage 1: After you have written a good draft, lay your work aside for several days, maybe even a week or more. If deadlines are imminent, at least take a break for a few hours. The psychological adjustment you can make by getting away from your own writing may actually save you time. When you pick up the paper again, try to read it as though you are completely unfamiliar with the report or the writing. Read through the paper without stopping to criticize small points just as though you were reading a published article by someone else. With the overall picture in mind, ask yourself whether "this author" is emphasizing the main point, whether he or she has organized the material in a logical and conventional order, and whether too much or too little is said. In other words, adopt an outsider's attitude and criticize the clarity in content and

organization. What questions would you have if you were not familiar with the work? Try to recognize whether the objectives, discussion, and details are clear to a reader. If not, begin work on those points without worrying about details of sentence structure and grammar. At this point, you are looking for general clarity, order, logic, and a focus on your point of emphasis.

Stage 2: When you have revised organization and development of content and are convinced that your main points are clear, read the revised version—this time much more slowly. Check content in each of the main sections of the paper—the abstract, the introduction, and so forth. For a research publication, carefully check the materials and methods. Could an outsider follow your instructions and produce the same experiment with the same results? Check your own data for accuracy. Look at the tables and figures and the text of the results and discussion. Can you simplify data for the outsider? Do you need to add a point or, more likely, can you delete some discussion or even a column in a table or a whole figure without distorting the data or diluting a point? Check tables and figures carefully not only for errors and clarity but also for how well the results are interpreted.

In the discussion, have you related your research to findings of others as revealed in literature? Check ideas in textual citations and in the references; consult the sources themselves for what they say. Have you distorted a citation with the context in which you refer to it? You are not going to do this sort of thing deliberately, of course, but it is easy to misinterpret an author or make an error in transferring details or ideas to your own words. Are your conclusions concise and do they clearly reflect the results?

Stage 3: After you have revised the content of your paper in this way, read it again very slowly, phrase by phrase. This time, watch the diction, small flaws in logic, and structure of the sentences. Does each statement support or disprove your hypothesis and your line of reasoning? Remember Day and Gastel (2006), Tichy and Fourdrinier (1988), Paradis and Zimmerman (2002), or Zinsser (1998). Are your sentences full of clutter? Rewrite them. Then, watch for transitions, precision, and details. Check accuracy in spellings, numbers, meanings of words, and adherence to publication style. Do not trust your good memory or your intuition. Especially check data against original records again, and verify the data points in tables and figures as well as the textual citations and references. If it has been some time since you did a literature search, check for recent publications on your subject and update your citations if need be.

After you have gone through these three stages in the first revisions, put the paper aside again for a while. Then read the paper through smoothly but slowly. **Read it aloud**. It is amazing what you hear that you will not catch when you read silently. Is there something you missed in the revisions? You may need to repeat one or more of the three stages again. Many people would do well to put the paper aside for several days and then go through the revision process step by step at least once more, but do not become obsessed with

finding errors. If you are satisfied that the paper is clear, the content is accurate, and it is free of grammatical errors, it is time to ask others for reviews.

9.2 REQUESTING OTHER REVIEWS

9.2.1 In-House Reviews

After your own reviewing and revising, you will do well to turn the criticism over to coauthors and in-house reviewers. Colleagues, supervisors, and editors can often serve as buffers between you and the audience and can have helpful suggestions. Choose reviewers carefully. It will be good to have one who is familiar with your work, but, like you, that one may know the subject so well that he or she will not catch all the points that would not be clear to the audience who know less about your research. A second reviewer might be someone familiar with science and the principles involved in your work but know few details of the specific subject of the paper. This one is closer to the audience. You may also want another reviewer whose expertise is in only one area, such as a statistician to check to see that you have presented your data in the best manner possible or someone skilled with composition who can point out discrepancies in organization or sentence structure. Almost all of us are myopic with our own work or too close to it to recognize those points that an audience might not understand. If the paper is a journal manuscript, it is important for these in-house reviewers to read the manuscript before you send it to the journal. Revise the paper after you receive their comments.

9.2.2 Reviews by Journal Editor and Reviewers

When you have revised according to your own and in-house reviews, then the manuscript can be ready for submitting for publication. Be sure it is ready. A reviewer for an international journal told me that one of his greatest frustrations is not the quality of the research but, rather, the quality of the manuscript. Some authors send papers to the journal that are not ready to review. The manuscript may have good science, but it is not clearly presented and is poorly written and replete with so many poor sentence structures and grammatical errors that the distractions obliterate the point of the paper. If the editor sends it back to the author with suggestions for a rewrite and receives another poorly written version, the paper may well be rejected.

Do not expect miracles from the journal editors and reviewers. Although peer reviewers are helpful, they will not rewrite your paper for you or make a good paper out of a bad one. With most professional journals, the reviewers are volunteering their time. The only compensation they get is the satisfaction of participating in professional responsibilities and protecting the reputation of the journal. Allow them time to do a good job. Treat the reviewers with respect by first getting the paper to the point where you think no further revisions are

needed and then by giving serious attention to their critical observations. You should expect outside reviewers to be candid with an author about strengths and weaknesses in the paper. Take seriously the review comments and use them to your advantage. You may not agree with your reviewers, but you should respect their opinions.

Again, your attitude is important. Be prepared to revise yet again. Even though you submitted the paper fully believing that it was in need of no further revision, you will need to revise after the reviews. I have worked with hundreds of refereed papers. **One** among them was accepted for publication by a refereed journal with no revision requested. That one was a methods paper by a graduate student. The chances are remote that your paper will win such a lottery.

If you expect to receive numerous suggestions for revision, you will be ready for what you receive. Read the reviews objectively. If your work is good, most reviewers are sincerely interested in helping to produce a good publication and are not trying to reject your paper. Approach all the reviews with this idea in mind, and try viewing your paper from their point of view. Your goal is to produce a better paper after acting upon their suggestions.

Bad reviews can happen to good papers. As Danielle Steele says, "A bad review is like baking a cake with all the best ingredients and having someone sit on it." Probably the worst reviews are the nonreviews or those that say very little. General comments such as "Tighten the organization" or "Well written, could add more data" are not very helpful. The reviewer needs to highlight points at which the organization is weak or where you need more supporting details and make suggestions for how to improve the communication. Without rewriting the paper, reviewers can and should be specific.

Editors try to choose reviewers who are working in areas closely related to the subject of your paper. Because they know the subject very well, they may question new ideas that have not commonly been accepted or that contradict their own assumptions. Do not let such people frustrate you. They can be unintentionally helpful. In their criticism, they will likely allude to the weakest parts of your paper, and even though you may not agree with their criticism, you can make the effort to strengthen that part of the manuscript and provide strong support for any new theories you present. Any reviewer who finds something wrong, weak, or difficult to comprehend is doing you and your paper a service no matter what his or her attitude is. The reviewer may not be able to specify what is not valid, but the fact that there is some question probably means some rewriting could improve your paper. Maintain your own confidence in what you are doing, and let the criticism lead you to a better paper.

Be open-minded but do not blindly follow suggestions by reviewers. They may be wrong about a point. You may need to explain to an editor why you have not followed a reviewer's suggestion, but remember that the paper belongs to you and any coauthors who are working with you. Reviewers are

people too; they make mistakes. Just do not conclude that the mistake is theirs until you have engaged in some objective self-criticism. Then with an open mind revise your paper yet again. Lay it aside for a few days, and then review it yourself. When you believe the accuracy and clarity of the paper are pristine, return it to the editor with a letter explaining how you have followed review comments and on what points you disagree with reviews and how you have accommodated the difference in opinions. If each author, reviewer, and editor in the publication process performs his or her responsibilities in a professional manner, we can all be proud of the scientific literature, including your paper.

9.3 REVIEWING JOURNAL MANUSCRIPTS FOR OTHERS

During your career as a scientist, you will receive requests to review manuscripts for others, especially manuscripts that are submitted to professional journals. Journal reviews can be full-blind reviews in which the authors' names are not revealed to the reviewer or the reviewer's name to the author. Or, at the other extreme, reviews are occasionally fully open; the author and the reviewer are not only identified to each other but also may even communicate with each other. Many reviews fall somewhere between these two extremes; often, the author does not know the reviewer, but the reviewer knows who the author is.

The peer review process for journal publication is certainly not foolproof, but it may be our best safeguard against too much inferior literature in the sciences. As a reviewer, reception of the paper by the audience is your chief concern, but you are in a position somewhere between the editor and the author. Try to understand whether your position is midway or skewed in one direction or the other. Sometimes the reviewer's major responsibility is to the author to help get the manuscript ready for an editor; sometimes the major responsibility is to the editor to help judge and justify the acceptance or rejection of the paper and make specific recommendations to the author. Whatever your position, you should carefully **evaluate the work to the benefit of both the editor and the author on behalf of the audience.** Keep in mind that yours are mere suggestions. It is not your responsibility to rewrite the paper. Both editing and rewriting are outside the realm of your responsibilities as a reviewer. Be certain the editor and author can understand your marks and comments on the paper. With the advent of computer technology has come the possibility of reviewing online. You may be able to mark suggestions and changes in a manuscript electronically. Take care to make any suggestion you have clear, and be sure that the editor and author can clearly distinguish the original text from your suggestions.

When you are reviewing a paper, three professional principles should be upmost in your mind. **First, do a good job.** Along with editors, reviewers are the guardians of the scientific literature; enough garbage slips into publication without your contributing to it by not giving due attention to a review. **Second, review in a timely manner.** Authors are anxious about their papers,

and journals need to publish research before it gets too stale. Get your review back to the editor in the time requested. **Third, keep information in the manuscript confidential.** The work is the property of the author. You may run across exciting ideas in your reviews, but they are not yours, and public disclosure or your own use of the information is unethical until the work is published and then clearly referenced.

As you review a paper for someone else, you can follow the same three-step plan presented previously in this chapter for reviewing your own paper. This time, however, you do not have the intervening revisions. You simply review and comment on major points, sections, and details from the same version. Keep in mind that your job as reviewer is not to revise but simply to make suggestions and let the authors act upon those suggestions as they see fit.

The reviewer's role is to peruse the entire contents with full attention to all details and accuracy in the communication. To be a full reviewer, you should be knowledgeable about the subject of the manuscript, you should have read much of the literature on the subject, and you should be familiar with the journal to which the manuscript is submitted and the audience who will be reading the published work. Only with this expertise can you judge overall quality in accuracy of scientific details and clarity in communication. Because the reviewer's role is one of assistance, you should maintain the attitude of humble but confident objectivity. The reviewer must express an opinion on the overall values of the manuscript and strengths and weaknesses in its component parts. Chapter 6 on peer review by Barbara A. Booth in *The ACS Style Guide* (Coghill and Garson, 2006) provides good information on the review process and the responsibilities of authors, reviewers, and editors. The checklists for reviewers in Peat et al. (2002) or Hofmann (2010) can be helpful for reviewing. In reviewing a manuscript for someone else, the following suggestions may prove useful.

Keep your own paper handy, or make a photocopy of the manuscript to work with. Initially at least, do not write on the original manuscript. You can well change your mind about your own opinions as you study the paper, or the editor or author may have requested that you not mark the copy. If you review online, be sure this technique will be accepted by the editor, and be cautious with any mark or suggestion you insert.

Read through the entire manuscript to gain a familiarity with it. Then read it carefully and consider the following questions: Is the research clearly justified and made credible with sound methods and data and with adherence to scientific principles and appropriate use the literature? Does the work add to the knowledge already available in a given area of study, or is it essentially a duplication of earlier publications?

If you can give positive replies to those questions, consider the research itself as depicted in the paper: Is it valid, complete, and credible? Are the hypothesis and objectives clear? Is the statistical design appropriate, and are the methods presented in adequate detail for a reader to repeat the

experimentation? Are the results clearly stated, and do the data support the interpretation given to the results? Are the data analyzed statistically, interpreted accurately, and presented in text, figures, or tables that are easily comprehensible?

Now read carefully again and consider the manuscript by parts and in detail. Are the main points emphasized? Is the title appropriate? Is the abstract the correct length, and does it contain the adequate details? Should some sections of the manuscript be deleted, revised, shortened, or expanded? Is the manuscript too long or wordy?

Then, as in reviewing your own work, go to the smaller details. Is organization within paragraphs clear, and is the sentence construction effective? Does the author follow the proper format for the text, tables, figures, and references? Are all important references cited, and are any of them simply excessive baggage? You may even mark misspellings or other mechanical and grammatical problems that you see in the writing. But remember that your role as a reviewer is not to be a technical editor, and you should not rewrite for the author or edit for the editor in your role as a reviewer. However, do give specific suggestions about a point you find weak.

You are making notes on all these matters or marking a work copy as you read and reread the paper. Prepare your comments for the editor and the author on the manuscript itself or write a critique on a separate sheet. Write your comments clearly with specific suggestions for how to make improvements. It does not mean much to an author or editor simply to say, "Not acceptable." What is not acceptable? Do you have a suggestion for making it acceptable? In other words, be specific without actually rewriting material.

Finally, ask yourself whether you can support your criticisms. Have you been helpful or prejudiced? And have you communicated your opinions clearly to the editor and the author? Study the well-done review in Appendix 7. **A good reviewer is invaluable; a bad one is demoralizing and destructive.**

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Chapter 10

Titles and Abstracts

Clutter is the disease of American writing. We are a society strangling in unnecessary words, circular constructions, pompous frills and meaningless jargon …. Simplify, simplify.

—William Zinsser

Titles and abstracts are the parts of your paper that will be read most often, and they may be the most difficult sections to compose effectively. What Zinsser (1998) says about avoiding clutter and sticking to simplicity is particularly true for titles and abstracts. They should be written with simplicity, clarity, and as few words as possible. They serve (1) to disclose the basic information in the paper and (2) to help readers decide whether to read the entire paper. Key words from the title and abstract are used for indexes for literature searches. Informative abstracts along with their titles are often abstracted for separate publication, and it is essential that each be an entity that can stand alone. As you write them, keep the purpose and audience clearly in mind, and keep them uncluttered and concise.

10.1 TITLES

The title may be the most notable phrase you write. The title is the first impression you make on your audience. It should attract attention, but most important, it should be informative. Many people will read it, but few will read the rest of your paper. It should use the following:

1. The most precise words possible
2. Words that indicate the main point of the paper
3. Words that lend themselves to indexing the subject.

One technique for creating a title is to write the objectives first and then write the rough title, which is sometimes called the *working title*. Go on to write the entire paper, and then rewrite the title. Write and revise the abstract, and then check the title again. It may need another revision.

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Common problems with titles are in their length and in the selection and arrangement of words. Be sure your title will make sense to someone not familiar with your subject. Use words that other readers might consult to find information such as your paper contains and use them in a sequence that is not ambiguous or misleading. Study your title for unnecessary words and put the most important ones first. Avoid abbreviations, trade names, and jargon. Provide adequate information but keep your title relatively short. Eight to twelve words is a good range to target. Scientific titles should not be newspaper headlines. Scientific readers are not looking for a journalistic sensation story; they want information. A full sentence with an active verb is usually not a good title. Just be informative and as specific as possible.

The journal may also request a *running title*, or *running head*. This is simply an abbreviated form of the title that appears on journal pages beyond the first page of an article. For more suggestions about titles, see Day and Gastel (2006). Hofmann (2010) has some examples of good and bad titles. Also, take a look at the versions of a title in Appendix 8. Style sheets of journals will give you details on what is expected in titles for their articles.

10.2 ABSTRACTS

Abstracts are of foremost importance to the research paper or proposal and are also used as a single entity for abstracting services or conferences. The word *abstract* is used loosely to refer to almost any brief account of a longer paper. The term is often applied to abbreviated forms or summaries of reports, proposals, reviews, posters, and presentations as well as journal articles. Content summaries such as descriptive summaries or executive summaries of proposals are sometimes referred to as abstracts, and conference proceedings sometimes publish extended abstracts.

The **descriptive abstract**, or indicative abstract, describes the contents of a paper but does not give a precise condensation of the information contained therein. Its contents would be relatively worthless if it were not accompanied by the report. It is the best form for some reports and reviews. Like a table of contents, it is helpful for a reader in deciding whether to read the entire paper. But one must read the entire paper for substance. Descriptive abstracts contain too little information to substitute for the informative abstract that most refereed journal articles require. They can be helpful summaries of reviews or reports and for papers presented at meetings, especially if research to be reported is not yet complete.

Conference proceedings may also publish **extended abstracts**, which are more lengthy than those for journal articles. They are still summaries of research studies but can contain more details of the methods or include more data (sometimes even a table or figure) than can an informative abstract of a journal article. The **executive summary** for a proposal is also longer than the abstract for a journal article and serves a different role for the audience.

It concentrates on the need, the feasibility, and the benefits of a proposed study. For further comment on the executive summary, see Chapter 5.

Do not let all this fuss over definitions confuse you. Just know that these strange breeds exist, and then recognize that for journal publications you need the **informative abstract**. Informative abstracts used with scientific journal articles are a more structured form than a loose definition permits. The organization follows that of the article, and the length is restricted. Like the report, this abstract must include the following:

1. The research objectives and rationale for conducting the investigation
2. The basic methods used
3. The results and significant conclusion that can be drawn.

Notice that the two parts generally included in the full paper that are omitted from the informative abstract are the literature review and the discussion. This abstract should contain no reference to the literature. A concluding statement may give an interpretation or conclusion to the results, but any lengthy discussion or speculation is out of place. Although some journals will require fewer words and some will allow more, many style sheets specify that the abstract should not exceed 200–250 words or 3–5% of the length of the paper and that the form should be one paragraph. This concise summary can be published alone or disseminated electronically as a complete document. Some societies publish collections of abstracts as in *Biological Abstracts*. Study the sample abstracts in Appendix 9. McMillan (2001) also presents and discusses some examples of abstracts.

The **structured abstract** as described by the *AMA Manual of Style* (Iverson et al., 2007) is a form of informative abstract with side headings of the several parts required in medical reports. Other style guides will give information on acceptable form and content for abstracts. Silyn-Roberts (2000) has a good chapter including checklists on the various kinds of abstracts. Study the journal to which you will submit a manuscript to obtain specific instructions and to read examples of published abstracts. You will find a few differences between journals, such as length allowed, but any informative abstract must do the following:

1. Show readers quickly whether the full report is valuable for their further study
2. Be extracted (abstracted) from the full report for separate publication or electronic distribution
3. Furnish terminology to help in literature searches by individuals or by literature retrieval specialists for indexes and electronic databases.

To serve these purposes, the informative abstract must be a short, concise, but completely self-explanatory report on a scientific investigation.

Although brief and concise, along with the essentials (i.e., research objectives, basic methods, and results), the informative abstract should maintain

clarity and avoid a choppy style that does not flow smoothly. Emphasize the main points and avoid long lists of information. In presenting the main points, be as specific as possible. For example, say "20 and 40 $kg\,ha^{-1}$ of nitrogen" and not just "two rates of nitrogen." Keep the tone strictly objective. Provide any scientific information, such as scientific names for species, that is important for a complete understanding of your subject. Avoid jargon, brand names, and abbreviations that are not immediately evident to the scientific community. Use no references to the literature or to any other material that would require a footnote or pursuit of external information.

When you think about it, all these requirements for the informative abstract simply emphasize its purpose: to be a concise, complete report of your work that can stand alone without further explanation. In addition to the references listed here, study titles and abstracts in the journals in your discipline and any instructions your publisher provides.

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Chapter 11

Publishing Data

Graphic excellence is that which gives to the viewer the greatest number of ideas in the shortest time with the least ink in the smallest place.

—Edward R. Tufte

Once you have analyzed the data from a research project, you are ready to put them into a form to communicate to others. Before you decide what form your data will take, consider your purpose in presenting the data and the audience for which it is intended. Ask yourself what point you wish to make. Also, be sure that you yourself understand the data and the analysis and firmly believe in what you are reporting. Then deliver the information with as much clarity as possible for the medium you are using—a journal article, a poster, a slide presentation, or other report.

You may be able to present data in the flow of the text. But often tables, graphs, maps, photographs, flow charts, or other figures or illustrations can communicate more clearly than can text. It is not realistic to try to use all the data points you collect during your experimentation. As Gastel (1983) suggests, "Good science communication, like good science, usually entails gathering much more information than will appear in print." Your job as a writer or speaker is to select **representative** data and to determine which form of presentation will be most clear for the audience. Some audiences need a simple table or figure and more verbal explanation, and they may not understand linear regressions or logarithmic scales or molecular graphics; others may be skeptical of your credibility if you do not use these forms.

Fortunately, we have a wide selection of formats to use for data presentation. Once you have the audience in mind, think in terms of which format will best express your point. You may be able to present simple data in a line or two of text. Sometimes a drawing or photograph can best show methods or results. **Tables** are excellent for presenting specific data and making exact comparisons between data points. Tables can also show gradations and relationships between controls and treatments. **Bar charts** are not as numerically specific as tables but can make more visually dramatic comparisons. Bar charts make comparisons in sizes, magnitudes, amounts, and other distinctions. They should emphasize

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differences rather than trends, but as with data in tables, the bars can be arranged to indicate a trend. Although measurements can be closely estimated relative to a scale on the axis, the purpose of a bar chart is not to show specific numbers, and seldom should you duplicate data by writing specific amounts above the bars. If you want the specific numbers, use a table. **Pie charts** can be a clear, simple way for showing parts of a whole or percentages. They are most effective when the pie has a limited number of slices. The smaller the slice, the more difficult it is to estimate the amount it represents. Small slices may benefit from use of contrasting colors. Slices can be labeled with amounts, but thin slices are difficult to label. **Line graphs** are designed to demonstrate movement, change, and trends, especially over time or concentrations. Like bar charts, their purpose is not to show specific amounts, but they can show estimates against a scale. The semilogarithmic line graph can demonstrate relative changes in two values. Molecular graphs can display such things as nucleotide sequences in DNA. Variations in tables, pie charts or line graphs, molecular graphs, and drawings or photographs give you a wide range of choices.

Select the forms that will make the audience interpret your data accurately. Many methods for data analysis and presentation are used. As with our discussion of other communication devices, the purpose here is to present the fundamentals for choosing and using a table or figure in a report. The tools you use for the figure or table will depend on the statistical analysis you use and the software you select for constructing and displaying them. The form you select for presenting your data should be the clearest and most honest representation of the data.

Results in a report are relatively easy to write or present once you have displayed your data in tables and figures and studied their meanings. Keep in mind the communication principle of simplicity. The simplest possible message is the most likely to be understood, but do not fragment the meaning by oversimplifying the data. Seldom, if ever, do you need to use both a table and a figure to express the same information in written work. For a slide presentation, you may want to use both in order to move from one slide to another and give the audience two views of an important point while you talk about it.

In any communication, misunderstanding is a danger. It is imperative that you present your results with every degree of clarity and honesty possible. Of course, deliberately loading data to make a point is strictly unethical, and even inadvertently giving the audience a false impression by inaccurate or sloppy presentation or a failure to adhere to conventional use of words, tables, and figures is as bad as guessing at measurements in the laboratory. Precision, accuracy, and honesty must continue throughout data analysis and presentation.

The ease with which data can be analyzed by computer and the comparable ease with which you can devise a table or a graph are invaluable. However, any technology or tool involves both beauty and danger. Computers add impressive dimensions to our abilities to be creative, but never distract the audience from

the scientific message in the communication. Recognize the conventions used in tables and illustrations of all kinds. The readers will interpret data according to conventions they are familiar with or by their visual perception of what appears most important. Tufte (2001) describes some of the pitfalls that occur with presentation of data in figures. These misconceptions result from visual or psychological illusions because of the arrangement of data relative to communication devices involving color, intensity, size, and spacing. Any amount of explanation will not completely overcome the psychological impact of a wide line compared to a narrow one or a large letter compared to a small one. Size suggests importance. The same would be true of a column of information in a table if it were set apart in some way with color, bold print, or spacing. Guard against misleading an audience with poorly presented data or with overly elaborate use of color and other options to the detriment of the message. With and without statistical analyses, your data can be complex. Your job is to present your data and its message with the greatest possible clarity. Every scientific experiment has exclusive variables or details that need to be emphasized, and results may require unique methods for presenting data clearly.

Because of the many differences in the display of data, you should study the journals published in your scientific discipline. Follow suggestions made in the style sheet. It is critical that you check the most up-to-date guidelines if you plan to publish. These guidelines or the editor can tell you what is acceptable and how to submit the form of data you use. As the Science Illustration Committee (Council of Biology Editors, 1988) concludes, "The simplest rule of thumb for the author and illustrator should be: Follow what you see in print." But be sure the printed versions you examine are recent ones in your own journal's style. Other information is in Chapter 15 on visual aids, and note examples of tables and figures in Appendix 10. Briscoe (1996) also gives good information and examples of figures. The following observations may also be helpful.

11.1 TABLES

If a table is used, do not repeat exactly what it says in the text—just call attention to or interpret its main points. A table should be able to stand alone—that is, to communicate a point or points without the need to refer to the text. Background material such as information on how an experiment was conducted will be given in the text, but the reader should be able to interpret data presented in a table without referring to the text. Abbreviations that cannot be used in the text are sometimes appropriate for tables, but meanings not immediately clear should be defined in the caption, in headnotes, or in footnotes. For clarity and understanding, a table may repeat information in more than one form. In addition to the absolute values presented, it may give percentages, totals, means, averages, or ratios of those values.

Authors are more likely to put too much rather than too little information in a table. Limit the items in the field, especially in tables used for slide

presentations. Often, full columns of information can be omitted. Be suspicious of any column that has few or no data points that differ. A string of zeros or any number in a column that repeatedly notes the same result can often be omitted. A full table consisting of no more than six or eight data points can usually be replaced by a sentence or two in the text. The same table may serve as a good visual aid in a slide or poster presentation where a full sentence would not as quickly display a point. Tables are also overloaded when headings and footnotes are too heavy. For example, if an abbreviation is obvious from information in the caption, that abbreviation can be used with no further explanation.

Problems that occur with tables can confuse readers. Errors can occur easily in transferring data to a table or in subsequent revisions. Captions, like titles, are sometimes too long and wordy; they should be concise and contain only the key words needed to clarify the message in the field of data. Numbers should show no more decimal places than are essential for reasonable precision and accuracy. As with other communication, try to consider your tables from the viewer's perspective. Make them precise, concise, and as simple as possible. The following briefly illustrates main parts of a table and the terminology usually used to name those parts:

TABLE NO. Caption or title

Main stub head	Boxhead or spanner heading (identifies items in field)[a]		
	Column heading #1[b]		Column heading #2
	Subhead #1	Subhead #2	
Stub heading #1[c]	Field item #1	Field item #2	Field item #3[d]
Stub heading #2	Field item #4	…	…
…	…	…	…

[a,b,c,d]*Footnotes in order top to bottom and horizontally.*

Characteristically, a table contains no vertical lines. Many computer programs provide an option to use grids in which to plot data. Look at the journals published in your discipline. Unless they regularly publish tables on grids, do not choose this option. Grid lines use ink for no real purpose. Three horizontal lines run the full width of the table—one beneath the caption and any headnotes, one beneath the headings for the stub and the field, and the third below the field and before any footnotes. Other horizontal lines, called straddle rules or spanners, run across all the columns of field items to which the heading above the spanner refers.

The spanner heading identifies items in columns, which should be the dependent variables, and the stub column heading identifies the independent variables for items in horizontal rows. Comparisons between like elements in the data should be made down columns, not across rows. A spanner heading should define the meaning of the items in the field by telling us whether those items are percentages, yields, concentrations, or other measures. Any subordinate heading simply adds precision to the main head. Use as few headings as possible to communicate clearly; only rarely should you go beyond tertiary headings. Be sure to include units of measure. For example, the main heading might read "Chlorine ($mg\,L^{-1}$)"; numbers in the field would be rather meaningless without the $mg\,L^{-1}$. The sequence of footnotes is carried horizontally across each line of entries from top to bottom in the table.

See sample tables in Appendix 10. Kulamer in the American Chemical Society manual (Coghill and Garson, 2006), Day and Gastel (2006) and Peat et al. (2002) provide discussion and illustrations for making and using tables and figures. For the specific stylistic details and illustrations for your discipline, consult your own journals and style manuals. Unless your style sheet specifies otherwise, you can use the following guidelines for tables.

11.1.1 Preparing Tables for Publication

1. First study the publisher's style sheet carefully and look at examples in the text.
2. Use Arabic numerals to number the tables.
3. Prepare tables with the like items, or items you want to compare, reading down columns, not across lines.
4. Group items logically with control values to establish a baseline for comparisons. Any gradation or trend in data should probably be stressed.
5. Round off numbers. Do not use excessive decimal places. Decimals must be aligned in columns.
6. Be sure the caption is descriptive of the table's contents. No verb is necessary in this caption.
7. Explain in the caption, in headnotes, or in footnotes all nonstandard abbreviations and symbols used.
8. Verify all information. Make sure that all data and statistical analyses are accurate. Verify again after any revision or transfer of information.
9. Check tables for accuracy in use of symbols, units of measure, and other labeling. Be consistent with such labeling among all tables and figures in the same text.
10. Proofread carefully.

11.1.2 Preparing Tables for Slides and Posters

Most of the previous suggestions apply equally to tables that are used in written reports or for other presentations. The audience for a poster or slide

presentation is not going to be able to study the table as long as the reader of a manuscript can study it, and so simplicity is even more essential. In publication, the use of symbols, shapes, sizes, and especially color may be limited, but the slide or poster can make important use of such symbolic language. If you are selective in the media you use and if you present your most representative data, your tables will lead the reader or viewer to the conclusion reflected by the full data. This is also true of figures.

11.2 FIGURES

Illustrations, or figures, come in various sizes and shapes. Photographs, drawings, flow charts, line graphs, bar graphs, molecular graphs, pie charts, maps, and variations of these forms can add a depth of meaning that is difficult to convey in words. In considering where and how to use an illustration, keep in mind the values and standards we are striving to achieve in scientific communication. Consider your purpose and what form best fits that purpose. Look at the nature of the data—numbers, ranges, differences, appearances—and what point you should make with the data. Try to determine how your audience will respond to the illustration. Will they see something different from what you see because they are not familiar with the information? Test your portrayal of data on someone not familiar with the point you wish to make. Be familiar with the conventions used with illustrations, including symbolic meanings that are expressed with lines, sizes, bars, numbers, colors, shading, and axes, as well as words. With all these things in mind and with an honest and sincere effort, you can produce an illustration that carries a simple, accurate message.

If illustrations are not clear, accurate, and appropriate, they are distractions and should be avoided. When you need to display specific values, a table is usually the better choice. A great deal that has been written about charts has to do with problems involved in their use, whether it is the difficulty in presenting the data, the difficulty in interpreting the data, or what Tufte (2001) calls "chartjunk" or others might call "noise." Anything that distracts, anything that is simply decorative, anything that is illegible, and anything without a positive communication value should not be used with scientific illustrations any more than such should be used with words or the data. Be sure that the end result of your presenting an illustration is that the audience concentrates on what is communicated, not how the image looks.

Computer software makes possible quick and accurate creation of figures. Find a software program that works well for your kind of data and then use it carefully. Most will allow you to draw boxes, shadows, and three-dimensional (3-D) bars. They provide some atrocious designs to fill the bars or place them in multiple rows with depth perception. Avoid these distractions. Keep your graphs simple; data are often difficult enough to comprehend without challenging the reader to see bars hidden behind bars or to be distracted or confused by strange or indistinct designs. Two questionable additions common in graphs in recent

years are grids and 3-D bars. Computers have made it easy to add these to the graphic design, but neither of them adds clarity to data. Tufte (2001) condemns "design variation" such as the 3-D effect, and he includes grids in "chartjunk." Briscoe (1996) says that 3-D is "an obtrusive element that distracts the viewer." Her comment on grids is that "Far from beautifying or compensating for the paucity of information, they usually clutter or confuse." Check samples in the journals in your discipline to determine forms that your editors prefer.

Designing illustrations and the graphic presentation of statistical data are subjects for entire books, and all of us could well benefit from a course on those subjects. The most that I can do is to introduce you to standards and values that I have encountered in working with scientific communications and to suggest other sources of information. First, as with tables, check your style manual, and then check the excellent information in Briscoe (1996) and Gustavii (2008) or that by Kulamer in the *ACS Style Guide* (Coghill and Garson, 2006). The book by Hodges et al. (2003) provides good material for the biological and medical sciences, for which drawings and other illustrations of plants and animals are extremely important. In that book, the chapter by Patrick J. Lynch has good information on charts and diagrams. Tufte (2001) has produced an interesting study of problems with visual display of data in figures and illustrations, and he explains and illustrates his points well with examples from published charts. He shows the "lie factor" that makes data appear to say something that is not true and "chartjunk" that simply adds distraction or false perception to an illustration. The data are the most important part of a graph. Tufte also discusses "data-ink." For example, in a bar chart, if you have a *y*-axis containing units of measure, to also write the value above the bar is redundant and that ink should be erased. In his words, "A large share of ink on a graphic should present data-information." Unnecessary use of ink does not increase our perception of the meaning of the data. It is beneficial to study Tufte's examples of chartjunk and lack of maximizing data-ink as well as his information on good displays of data.

Explore these sources along with illustrations in the journals in your discipline, and you will come away with a basic understanding and respect for standards in visual display. You will also find what works best for the presentation of your data. Remember that modifications of these principles may be needed if your data demand a different format or statistical analysis. However, always choose the clearest, most complete form possible to make your point to an audience. As with any communication, one audience may require more detail than another. Along with the information from your style manual, consider the following basic principles for producing graphs and other figures, and note the examples in Appendix 10.

11.2.1 Preparing Graphs and Other Figures

1. Be sure the graph carries your point better than the text or a table would. If the figure becomes complex and requires extensive explanation, reconsider, divide the data, or try something different.

2. Consider what kind of illustration you need: a photo, a line drawing, or a graph. What kind of graph would be best—line, bar, pie?
3. Make it simple. A figure should be comprehended quickly. Draw graphs to agree exactly with experimental data, but do not overload them with information.
4. Limit the number of curves or bars on a graph. A single figure can hardly communicate clearly with more than three to five lines or 8–10 bars (more than 10 bars can be clear if they are grouped).
5. Plot any independent variable on the horizontal (x) axis, or abscissa, and the dependent variable on the vertical (y) axis, or ordinate.
6. Avoid wasted space. Scale details to agree with the data, but do not extend the axes beyond the point needed. Put the legend into the field of the graph if possible, and do not put a box around it.
7. Label all axes carefully and show units of measure. Use tics and subtics to subdivide the axis so that you do not overcrowd it with numbers.
8. On bar charts and linear line graphs, most scales should start with zero. If you must compress scales with slash marks or start beyond zero, be sure this modification is clear.
9. Remember that position, size, shape, length, symbols, angle, and color are all visual codes that carry messages to a reader. Do not let them convey the wrong message.
10. Select the size and format to fit the journal or other use for which the visual is intended. (Avoid color for most publications; use color in posters and slides.)
11. If a set of graphs is used in the same paper, poster, or slide set, be consistent and uniform in your use of all visual and verbal codes.
12. For a journal publication, consult your editor or follow guidelines for authors. Electronic publication may determine how your figures as well as tables and text should be submitted.

11.2.2 Bar Charts

1. Bar charts often have just one measurable axis. If they have two, they are sometimes called histograms.
2. Bar charts can be presented for data collected at even or uneven intervals.
3. The bars should be wider than the spaces between them.
4. Use conservative patterns (solids, shading, or hatch marks) to differentiate bars. For posters and slides, color is preferable.
5. Show significant differences with a least-significant-difference bar or with letters or asterisks above bars.

11.2.3 Line Graphs

1. Line graphs should have two axes. Avoid a third axis, if possible.
2. Simple line graphs should present data collected at regular intervals to show trends without extrapolation between data points.

3. The curves should be the boldest lines. Axes and tic marks should be less bold.
4. Be careful with line patterns. Dots, hyphens, or slashes can become confusing. Sometimes it is better to use distinct symbols (▲, ●, ■) rather than line patterns. Use distinctive colors for lines on posters or in slides.
5. Plot the length of intervals on both axes so that slopes are not excessively flat or steep.

11.3 SUMMARY

Whether you use tables, figures, or other visual illustrations to depict your data, be sure to submit high-quality copies for publication, slides, and posters. An out-of-focus photograph or a graph filled with chartjunk (Tufte, 2001) will merely distract from what you want to say. Symbolic communication with or without accompanying words is a strong form of communication. Be certain that it carries the right message.

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Chapter 12

Professionalism, Ethics, and Legal Issues

Whatever the rationalization is, in the last analysis one can no more be a little bit dishonest than one can be a little bit pregnant.

—C. Ian Jackson

Professional ethics have to do with one's professional behavior as it affects others. Ethics are determined by individual, cultural, social, and professional values and may not be governed by laws. Because human values dictate ethics, the standards and beliefs can differ between individuals, groups, and cultures. Professional behavior relative to communication may be governed by policies or codes of ethics of a society, a company, an agency, or a publisher, and your ethical decisions should be made with full knowledge of these policies. Laws are created in an attempt to apply the same rules for all those under the same government. However, both laws and ethics result in behaviors important to human interactions. In scientific communication, professional ethics, copyrights, and patents are among the main issues of ethical and legal concern. All these things are influenced by the profession to which you belong, but the responsibility for the actions and behavior is yours alone.

12.1 PROFESSIONALISM

Your individual actions and behavior will depend not on your profession but on your professionalism. As with many words, to define *profession* outside its use in a particular semantic environment is rather futile. It may be defined by distinctive characteristics as a professional athlete as opposed to an amateur who is not paid for the performance. Adding *al* to *profession* makes the word applicable to almost any career position. The word may simply be defined as a job or a career. Certainly, plumbing is a profession to many people. Academically, some will argue that real professions are only those of such people as physicians, lawyers, clergy, educators, engineers, or others who have a high degree of education, work in an area that is of service to others, are autonomous in governing their decisions, have a specialized expertise, and are expected to abide by standards of the profession usually agreed upon by a society or association.

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If we add the suffix *ism* to *professional*, we have a word we can work with. Except when it is referring to a historical movement, any "ism" is a concept, not a tangible thing, and is defined by its characteristics and the behavior of its adherents. Characteristics of professionalism can be found with any job or profession, whether it is that of custodian, clown, teacher, or brain surgeon. The ethical standards you are asked to follow rest, to a large extent, with a code of your profession. Doctors are concerned with issues that lawyers may find irrelevant to their work. Specialized scientists may need licenses or certifications for their work, but with or without such qualifications, all can exhibit professionalism or professional behavior. An understanding of professionalism here is extremely important to scientific communication and ethics.

The professional is knowledgeable, skillful, dedicated, and honest. He or she is trustworthy, has a good work ethic, is respectful of others, and is willing to serve professional, not just personal, interests. You can think of other terms that will describe such an individual, and although it is true that none of us are perfect professionals, it is a goal to set for yourself. Your professional reputation as well as your communication skills will improve as you attempt more and more to become the true professional in your field. Keep these ideas in mind as you think about the ethical and legal issues involved in scientific communication.

12.2 PROFESSIONAL ETHICS IN SCIENTIFIC COMMUNICATION

Good scientists maintain high ethical and professional standards. As scientists, they are interested in discovering consistent facts and theories in the empirical world. Any communications among them must be carried out with a high degree of accuracy and integrity. It is in their best interests to protect the pool of scientific knowledge from any fabricated data or conclusions based on insufficient evidence and to maintain the respect of other members of the profession as well as members of society that are affected by their work. But human errors do occur, some people do not value honesty above personal gain and recognition, and good things can happen to bad people. Isolated instances of scientific fraud have been found even among supposedly reputable researchers. Every scientist is responsible for protecting the integrity of science.

In scientific communication, two kinds of ethical errors are unforgivable—distorting your own data and plagiarizing the work of others. Other breaches of integrity are also deplorable but sometimes difficult to diagnose. Most difficult is recognizing your own bias and admitting that even you can rationalize honesty. It is not always easy to mark the dividing line between accuracy and assumption, and all of us can err. Such errors can be made inadvertently with no intent to lie or deceive, but for that reason they are all the more important. You have to discipline yourself to demand care, accuracy, and objectivity in every instance of your research and communication of your findings.

Distorting data intentionally is inexcusable, but that which is not intentional can also be detrimental to science and to your reputation. It is easy to see the dishonesty when you change numbers in a data column, but what of the situation in which you believe a result should occur, the data almost point in that direction, and to delete one experiment would take care of the *almost*. Can you delete that experiment? Was that odd data set simply an anomaly that should not be considered anyway? Is there a typographical error or erroneous transcription in your data? Do you have time to experiment further to substantiate what you believe should have resulted? These questions are not easy to answer, and often no one except you can answer them. You can become so overly meticulous that you are ineffective, or you can rationalize your way into really dishonest reporting. Your scientific integrity is based on careful scrutiny of your work and sound judgment and objectivity in how you answer the questions involved.

The Committee on Science, Engineering, and Public Policy (1995) suggests that "social and personal beliefs—including philosophical, thematic, religious, cultural, political, and economic beliefs—can shape scientific judgment in fundamental ways." Individual and cultural prejudices have troubled scientific research and reporting for centuries, and we are not without prejudices today. In *The Mismeasure of Man*, Gould (1981) exposes a social prejudice that has produced "documented" studies on biological determinism to prove that some groups of people are inferior to others (e.g. women to men). As "proof," these studies have used selected criteria that fail to reflect a total physical reality. Gould's conclusions should bring a degree of humility to all of us: (1) "No set of factors has any claim to exclusive concordance with the real world," and (2) "any single set of factors can be interpreted in a variety of ways." Think about those remarks when you conclude that you have discovered "truth."

Unintentional errors that yield inaccurate information also affect communication. We know when we speak or write an outright lie, but we must also be sure our statements are not misleading and ambiguous. A major difference between scientific writing and creative writing is that in creative writing we can allow the readers to interpret as they choose. Ambiguities and double meanings can simply add interest. We are not allowed that avenue in scientific communication. Read your sentences carefully to be sure that they will not be easily misinterpreted. The same is true for tabular or graphic portrayal of data. An inaccurate number or a visual deception in a graph can misdirect a reader. Your responsibility is to know the conventions for data presentation and check the accuracy of all details. Careful research, use of scientific reasoning, an open mind, clear and accurate communication, and a willingness to be honest at all costs will generally result in good ethical conduct. Settle for nothing less in yourself and your colleagues.

Plagiarism is inexcusable in any communication. It is both a legal and an ethical issue. A dictionary will define the term as some kind of literary theft or stealing. Ethically, it is disrespect and lack of recognition of the ownership of

the property of other writers. Plagiarism may be defined differently in other cultures. It is critical that international students understand the definition used in Western cultures and specifically that adopted by the university and department in which they work.

The definition of the Council of Science Editors (2006) states: "Plagiarism—misrepresenting ideas or words taken from the intellectual efforts of another as one's own or without crediting the source—is a serious ethical breach because it involves a deception that places personal interests ahead of giving credit where it is actually due." Like other forms of dishonesty, plagiarism is easy to distinguish when it is blatant. You lift words from someone else's work without giving due credit. That is clearly plagiarism. But how about ideas or words that are not quite the same but mean the same thing? Or how about picking up from your subconscious something you have read and thinking it is your own idea? These nebulous situations occur, and we cannot always be afraid that we may be using ideas that are not entirely original, but we must give due credit for both words and ideas. To guard against plagiarism or a failure to document sources, be familiar with the literature in your discipline.

The American Medical Association's style manual (Iverson et al., 2007) describes four kinds of plagiarism: direct, mosaic, paraphrase, and insufficient acknowledgment. Direct plagiarism simply uses ideas and words with no credit to their author. For mosaic plagiarism, an author mixes the ideas and words with his or her own and takes credit for all of them. Paraphrase uses another author's meanings or synonyms of words in a different arrangement but with the original meaning and without credit. Insufficient acknowledgment fails to credit an author in such a way that it is not clear what is borrowed from that author. These four forms are all bad, but it may be that some students and professional writers do not recognize all of them as plagiarism. Of course, you should refer to the opinions or results from other researchers and give due credit, but too much reliance on another's ideas to establish your own paper or just reporting another writer's ideas into your own words with or without citation and documentation can constitute plagiarism as surely as if you had used their words. Also, to publish all or part of a work of your own in two different publications is considered self-plagiarism and is certainly unethical even if you are the owner of the copyright. If you truly need to accompany a new publication with part of your own previous publication, such as a table, figure, or verbal explanation, either refer to the original and do not repeat it or repeat and clearly reference the specific source in which it was first published.

Plagiarism can also result from simple ignorance in how to reference other works or in sloppy, careless documentation. Careful documentation and verification of your references as well as clear knowledge of what has been done in your area of study are essential. Learn the accepted conventions for documenting the work of others and for obtaining copyright permission. When you question your right to use the words or ideas of others, find answers to those questions before you proceed. Some answers may be found in this text, but

when questions remain, go to other sources. Ignorance is no excuse, and violations, even unintentional, can destroy a career.

12.3 PROFESSIONAL RESPECT FOR OTHERS

Other questions of professional ethics have to do with your relationship with other scientists and with any professional group to which you belong. Candid sharing of scientific findings and maintaining the confidence of others are essential to your being an ethical scientist. The society or registry in your discipline probably has a code of ethics that you should study and use as a model. Be conscious of what constitutes fraud, conflicts of interest, and the need for confidentiality. Your colleagues soon learn to what extent you can be trusted.

Ethics are matters of making good decisions about questions of appropriate conduct regarding your work and that of others. There is often no legal retribution for offenders of codes of ethics, but your ethics relative to your behavior in your association with colleagues are instrumental to your reputation and the acceptance of your communication efforts. Your colleagues and your professional society may provide some guidelines, but unfortunately, no definitive rules regarding ethical judgments exist. Almost every situation demands an individual consideration, and you must draw your own conclusions. Consider the following issues that you will probably encounter in your career as a scientist.

12.3.1 Authorship

Giving appropriate credit to others is important in your reference to their work and in recognizing colleagues as coauthors. It is equally important that undue credit not be given. Questions of junior or senior authorship and of who should be included as an author are not always easy to answer. If you are a graduate student or a junior scientist, discuss with your advisor authorship and the order of authors on a paper or presentation. The Council of Science Editors (2006) states that an author of a research report should be able to take responsibility for the work by "participating in designing the research, carrying it out, and writing or revising drafts of the article." That means that any coauthor should be able to answer questions asked about the contents of a publication. Despite what some may call honorary collaboration or honorary authorship, any author listed on a paper should have contributed substantially both to the work and to development of the manuscript or presentation. Giving false authorship a nice name does not make it ethical. For information on authorships and making ethical judgments, read Macrina (2000) or *On Being a Scientist* (Committee on Science, Engineering, and Public Policy, 1995) or your own professional style manual.

12.3.2 Respect Your Data

Scientific progress is a continually evolving process. Your work today depends on results of work done in the past, and the future will look to work done today.

FIGURE 12.1 Trimming or cooking your data is as bad as reporting false data.

Scientists must be able to trust their predecessors and colleagues in reporting data. Do not make up your mind about your results before your data are collected and analyzed. Trimming, cooking, or otherwise manipulating data is as bad as reporting false data (Figure 12.1). Be careful with your own prejudices and biases, and be cautious when you work with others, especially with specialized scientists, whose input into your work may not be clear to you. In working across disciplines, researchers have to trust one another for ideas and analyses that their own disciplines do not include. The same is true with specialized statisticians who often know little about your science but can plot and analyze your data in a variety of ways. They can contribute invaluable expertise to a project, but they may not recognize the relative importance of your scientific variables. You need to understand links between your work and that of your colleagues and be familiar with the meaning of any input used with your data.

12.3.3 Be Careful with Confidentiality

In your own laboratory, information may be available that should not be disclosed to others until experimentation is complete and researchers are ready to publish their findings. Or you may review a paper for someone and find

interesting information that should be held in confidence until that paper is accepted and published. Also, a pending patent may make it unwise to disclose information. Scientists have an obligation to share information, and the obligation to keep information in confidence for a funding agency may result in a conflict of interest. All parties involved need to understand when disclosure of information is acceptable. At professional meetings, scientists should certainly exchange ideas, but take care in making positive pronouncements on unsubstantiated results. Disclosure or information release to the press before publication or before experimentation and analyses are completed should be handled with caution.

12.3.4 Do Not Publish the Same Thing Twice

To publish the same data in more than one scientific outlet is not only unwise but also contrary to most publishers' policies. It can also constitute self-plagiarism. If you need to convey the same information to two audiences, such as the scientific community and the public, two publications might be based on the same experimentation but would be presented in different ways, and it is important to report to the publishers that the information appears elsewhere. To submit results of the same research in two scientific journals is unethical even if you completely rewrite the text. Too much scientific literature already exists to ask an audience to read the same thing twice, and journal editors and reviewers put too much time and effort into getting a paper ready for publication to be told you are having it published elsewhere. Be sure one publisher has released your manuscript before you ask another to consider it.

12.3.5 Acknowledge Your Errors

You are human; you can and will make mistakes. If, in all sincerity, you say or write something that you find later is misleading or untrue, try to right the situation by acknowledging that error immediately. To make a mistake is one thing; to allow people to continue to be deceived is another. Your colleagues are also human; they make mistakes. They will respect you far more if you acknowledge an error than if you ignore it, even if the intent to deceive was never present.

12.3.6 Support an Ethical Workplace

When you agree to work for a company, an agency, or an institution, you are also agreeing to abide by the policies of that employer. Many of them have specific requirements relative to communication of information. You may need to have approval for any paper published, speech made, or meetings attended. The employer may also trust you with confidential information that you should protect from unwise disclosure. Sometimes your own values may not concur with the policies of your employer. Ethical decisions on what to do can

then be difficult. If possible, know your employer's policies before you accept a position and abide by them insofar as they are within the law and conform to your ethical and professional standards. If you are uncomfortable with your employer's policies, you would do well to find another job.

12.3.7 Respect the Time of Others

If you are asked to contribute to a paper as a coauthor, get your part done expeditiously so that you do not delay the publication for other authors. The same is true when you review a paper for others. Get the review completed in a timely manner so the author or editor is not unduly delayed. You should also be considerate of a fellow scientist's personal and professional time. Lengthy consultation should be a matter of mutual agreement and benefit. If someone generously provides time for consulting about your research, be sure that you acknowledge the contributions made.

12.3.8 Watch Out for Conflicts of Interest

Like plagiarism, blatant conflicts of interest and nepotism that influence ethical judgment are easily recognized. Trying to mix a personal relationship with a professional one or overlapping two professional activities can result in conflicts of interest. Any personal or business relationship should not interfere with your work as a scientist and a professional or your honesty in communication. Loyalty to an employer should not lead you to a biased report on research you are doing or failure to make clear what funds are supporting your work. Business partnerships with an advisor who has some authority over your degree program or research are questionable, as is having someone even distantly related to you serve on your graduate committee or as your employee. Remember that there are no definitive rules. A father and daughter could become a highly ethical research team or great business partners. But treat any possible conflict of interest with great caution. The scientist must avoid any personal bias in his or her judgments. Be aware of university or company policies regarding conflicts of interest. Your university may provide these policies in a handbook or pamphlet on the rights of graduate students.

12.3.9 Be Fair with Your Time and Effort

Conflicts of interest involve personal and professional relationships with others, or you may find issues in your individual work competing for your time, energy, and effort. Scientists can become involved in many activities—research, teaching, grant seeking, professional obligations to society, consulting, speaking engagements, seminars, workshops, travel, advising, and myriad other activities. Quality of any one activity can suffer at the expense of the others. To

assume a responsibility and do a poor job can be worse than refusing to assume the responsibility. Only you (and perhaps your supervisor) can determine where your responsibilities lie and how far you can extend your time and energy effectively.

12.3.10 Avoid the Sin of Omission

Refusal to assume a reasonable workload can be equally as irresponsible as trying to do too much. It may be difficult to believe that you can be accused of unethical actions if you do nothing, but breaches of conduct come with omission as well as commission. As a scientist, you will often be asked to contribute your expertise to a collaborative project. You may be asked to serve on professional committees to review and judge proposals or to be a reviewer or associate editor for a journal. You will have to be discreet in determining how much you can do and still maintain quality work. You cannot yield to every request for your time and energy. On the other hand, to reject reasonable requests to serve your science or your profession is just as unethical and can hurt your professional reputation.

12.3.11 Watch the Company You Keep

You may be totally honest, but if you collaborate in your research with unscrupulous individuals, their reputations will rub off on yours. Be alert to how your colleagues are received in the scientific community. And as you work with a fellow scientist, observe the care he or she takes with accuracy and the truth. You can usually recognize unethical behavior if you are conscientious and alert to it.

12.3.12 Be Firm with Your Own Ethical Standards

If you have not had an opportunity to take a course in ethics, consult texts such as those of Bayles (1989) and Macrina (2000) and be sure you can define ethics relative to your values and those of your profession. Professional reputations and scientific values depend on scientific integrity. Objectivity and scientific methods are only as honest and unbiased as the researcher or communicator who uses them.

Beyond a reasonable point in the critical review processes, we have to trust each other to be honest and accurate. Generally speaking, scientists are honest people. Those who cannot be trusted in their experimentation or reporting have no place in the world of science. But devils do exist, and we must constantly be alert to unethical and unprofessional behavior. The least you must do is to control your own behavior and uphold the highest ethical standards. As Thomas Carlyle said, "Make yourself an honest man, and then you may be sure that there is one rascal less in the world."

12.4 THE LEGAL ISSUES: COPYRIGHTS AND PATENTS

Sometimes the message you want to communicate to other scientists is a simple "It's mine." Or you may wish to make use of someone else's printed or electronic creation. In either situation, you are dealing with legal as well as ethical issues. Laws governing copyrights, patents, and trademarks protect the property of individuals and groups. Scientists must use each other's ideas and inventions, or we would not make much progress, but be sure you give credit to your sources and ask permission when you make use of the work of others. You will also be asked to grant permission to others. Know your legal rights, but recognize the need to exchange information with other scientists. If serious questions on acquiring or using copyrights and patents arise, I suggest you consult a lawyer knowledgeable on the subject. A few notes on copyrights and patents are included here.

12.4.1 Copyright

You own the copyright on any **tangible expression** that you create. Along with other forms, tangible expressions include written words, illustrations, printed or electronically disseminated works, electronic software, and recordings. Copyright does not cover the ideas, procedures, processes, concepts, or discoveries contained in such works. Protection of those things can sometimes be obtained through patents. Copyright registration is not a condition required for copyright ownership. Statutory copyright begins when the document is created, but protection and appropriate use of your work are increased when you have the copyright registered. If a work is not yours, find out whose it is before you use it. The author involved with scientific communications needs to be conscious of copyright privileges and regulations. You will need to know how to register a copyright for yourself, how to grant permission, and how to obtain permission for use of works from other copyright holders. The following are some handy things to know about copyrights in the United States, but consult other sources including the copyright law or a lawyer when you have important questions on copyright:

- **Both published and unpublished works** in any tangible medium of expression are protected by copyright and may be registered with the Office of Copyright. Whether it is registered or not, copyright protects only the **expression** of an idea (the words or other tangible expression), not the idea itself.
- **Registration of copyright** can be obtained any time throughout the copyright duration. For information on registration of copyright, you may write to the Copyright Office, Library of Congress, Washington, DC 20559. Or check the website at www.loc.gov/copyright. For written scientific work, you will want the forms under nondramatic literary works.
- **Duration** of copyrights generally protects works in the United States until the death of the author plus 70 years thereafter.

- **Works for hire** are those expressions or inventions that an employer requires or commissions you to create as a part of your job. In other words, you are being paid to create something, and any copyright, patent, or other benefit that comes from the creation belongs to the employer.
- **All works prepared by officers or employees of the U.S. Government** as part of their official duties are in the public domain. You do not have to obtain permission to use these materials, but you will still document your source.
- **"Fair use"** is not clearly defined and may hinge on the decision of a judge, but it generally means use for your own educational purposes as opposed to use for commercial gain. This definition is certainly oversimplified and incomplete. If you question your rights to use the works of others, consult an authority or apply to the copyright holder for permission to use the work.
- **Electronic communication** has added a new dimension to copyright. Profiting from work created by someone else is unacceptable even if it is accessible to you. New laws are being considered for how to copyright and document electronic communication. Be alert to developments in this area.

12.4.1.1 To Grant Copyright Permission

From offices of journals in which your work is published, you may receive a form that you and any coauthors will sign to transfer copyright or to grant printing and reprinting rights to the journal. Some publishers may ask that you transfer the copyright so that they are the owners, and you must refer to them any requests, including your own, for permission to use the work. Others are simply asking that you grant them permission for reprinting and distributing the work. In this case, you still own the copyright.

If individuals ask for permission to use your work or a part of your work, they may send a form to be signed or a letter requesting permission. Be sure the exact portions of works to be used are fully described or copied and that the description or copy is kept with the signed permission granted. Keep this information on file along with specific details on where and when the material will be used. Request that persons using your material clearly acknowledge both the source from which it came and you and any coauthors.

12.4.1.2 To Obtain Copyright Permission

When you know who the owner of the copyright is, write directly to that person, publisher, or agency for permission. You should begin efforts to obtain any copyright permission as soon as you know that you want to use the material. You may want to make a phone call to locate the copyright holder and to find out whether he or she is amenable to your using the material. However, a phone call will not constitute evidence that you have been granted the permission. You need specific information in writing, and this process may take weeks or months. You can delay your own publication by waiting too late to apply for copyright permission.

In requesting permission to use another author's or publisher's work, clearly identify the specific material to be used, including the following:

1. Author(s)
2. Title
3. Date of publication
4. Publisher
5. Specific selection to be used
   a. The form (as table, photograph, text)
   b. A description of the content (perhaps include a photocopy of the material you will use)
   c. Pages on which it appears in the original text.

Tell the agency or person to whom you apply where, when, and how you will use the material requested; whether your work will be published and what form it will take; and who the audience will be. Indicate that you will give full credit to the author(s) and publisher, and be sure that you do so. You will use a form letter or an e-mail template in obtaining copyright permission, and both you and the grantor will want a copy for your files. Keep a clear record of permission received. A sample letter requesting copyright permission is in Appendix 11.

12.4.2 Patents

Where they are applicable, patents are more versatile and offer more protection than copyrights, but they are not applicable to the expression of ideas. Patents protect the ideas as they are put into physical practice as machines, manufacture, processes, living forms, or composition. Copyright protection begins as soon as the expression is created; patents must be registered to serve as protection. Most patents are protected for 17 years—a much shorter period than for copyrights. Work for hire is applicable to both copyrights and patents. The remarks here on patents apply to U.S. patents only.

For the sake of simplicity, I refer to any patentable creation as an "invention," but patents can be obtained on diverse items, including synthesized materials and life-forms. As with copyright for electronic communications, biotechnology has added a new dimension to patents. It is now possible to patent life-forms if they have been synthesized by human efforts and do not exist in nature without human intervention.

Any invention that is patented must be proven to be **novel**, **not obvious**, and **useful**. In applying for the patent, you must give evidence that your invention has all three of these characteristics. The three overlap in meaning. **Novel** simply means that your invention is new, that a like invention did not exist before yours. **Not obvious** means that what you have put together is not something that anyone might immediately derive from the same materials. Your

invention is **useful** or needed, but no one else has come up with a way to fill that use or need in the same way.

Several communication efforts are important relative to patents. First, you must disclose to the U.S. Patent and Trademark Office any information you have on how the invention works, its components, and any similar inventions already in existence. These disclosures require that you carefully search and read the literature on your subject. Any failure to disclose similar inventions already in existence can thwart your chances of obtaining a patent, even if you did not know about the existing invention.

An important question relative to communications and patents is that of when to publish information about your invention. If you describe your invention to the public before you have registered the patent, it is considered public information and will probably not be patented. Before applying for a patent, be careful about presenting a paper on your invention at a professional meeting, publishing a journal article about it, or even describing it to anyone beyond confidential disclosure to colleagues who can be trusted to respect your claim to ownership. Although the same is not true in many other countries, in the United States, if you publish information about your invention before you realize that you should obtain a patent on it, you can apply for a 1-year "grace period" for filing the patent application, but remember that you must be able to prove that you invented it first. Someone else may already be using the idea or even applying for patent. Records that you keep as you are working on the invention can be essential to proving that the invention is yours. Keep careful, dated records, and if you foresee that you might be seeking a patent, have witnesses sign and date information that you record along the way.

Finally, perhaps most important to scientific communications is the patent literature. The disclosures on how inventions are produced and how they function are published and offer a storehouse of information helpful to other scientists. Certainly, the information on patents contains useful ideas, and you should not neglect to explore them for your research subject.

If you are thinking of patenting an invention, you are sure to have numerous questions that I cannot answer. You may obtain answers by visiting the government website, www.uspto.gov, or other sites on the Internet. Complexities arise in the patenting process that often require the services of a lawyer specialized in the area. In fact, one of the first things you may want to consider is hiring a patent attorney to deal with the patent office in proving that your invention is novel, non-obvious, and useful. Information on the Internet or in books on the subject of patents may also prove useful, but the government patent office is the final authority. Wherry (1995) gives basic definitions and information on patents as well as trademarks and suggestions for searching patent literature. Thomas D. Mays in Macrina (2000) offers succinct information on both copyrights and patents as well as other ownership of intellectual property.

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Chapter 13

Scientific Presentations

Nothing clarifies ideas in one's mind so much as explaining them to other people.
—Vernon Booth

Presentations at professional meetings and elsewhere are extremely important to scientific communication and to you and your career as a scientist. A well-done presentation can boost your professional reputation. Scientists build on the discoveries of others through communication, and your own ability to speak and present visual aids may mean the difference in your getting a job or a promotion. Applicants for a position often will have equally impressive resumes describing their academic knowledge and technical skills; the ones who get the jobs are those who exhibit their knowledge and skill in a presentation. In addition, you can learn a great deal from presentations by others but also from your own presentation and the questions and discussion that can accompany it. As Booth (1998) suggests, making a presentation can increase your understanding of your own subject. Take advantage of any opportunity to polish your speaking skills.

You will probably be required to make one or more presentations while you are in graduate school. You may even have a seminar course in your department in which you and other graduate students regularly deliver presentations. Also, attend other seminars and special lectures, and observe good and bad techniques in delivery as well as the content of speeches and the effectiveness of the visual aids. Valuable experience can be gained by attending presentations either as the speaker or as a listener. Use every opportunity available to take oral and poster presentations to professional meetings. You may encounter prospective employers for whom you will later make another presentation at a job interview. Whether it is a departmental seminar, participation in a national meeting, an informal or formal speech, or a job interview, you must perform well when you are "on stage" to become recognized as competent and articulate—two qualities essential to your success as a scientist.

13.1 ACADEMIC SEMINARS

A specific schedule for seminar presentations may be set up in your department. Graduate students and other speakers will present information on their

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research, on the scientific literature, or on other subjects of interest to the department. As a graduate student, keep in mind that you are talking to the people who know you best, but they are also the people who will or will not recommend you for career positions. Whether it is evident or not, professors evaluate your research and communication skills throughout your graduate work and especially when you make a presentation in a class or for a departmental seminar session. Attendance at these seminars is usually considered one of your professional or academic responsibilities, and participation offers you several advantages.

13.1.1 Seminars Provide Information About Current Research

For both the speaker and the audience, seminars present a unique educational opportunity. Every discipline includes a broad range of subject matter. You cannot expect to become proficient in all areas, but you can obtain some knowledge of and respect for the work being done in specialized areas outside your own. Conversely, in presenting your own research to those in related but different areas, you are providing them with another view of their discipline.

13.1.2 Seminar Presentations Provide New Perspectives for Your Own Work

When you prepare and deliver a presentation, your understanding of your own study increases. As Vernon Booth (1998) suggests, "Nothing clarifies ideas in one's mind so much as explaining them to other people." The learning that takes place in making your own presentation or observing others will give you new ideas to improve your research. From others who discuss their research proposals, methods, and results, you will acquire information to apply to your own work. Question–answer and discussion sessions present a means for uncovering errors, picking up new ideas, and strengthening your own research. Constructive, professional criticism is always beneficial both for the beginning scientist and for the experienced professional.

13.1.3 Seminar Presentations Increase Your Ability to Evaluate Research

As a young scientist, you soon learn that neither the scientist nor the science is infallible. Much time, effort, and objective criticism are required to judge whether a scientific paper or presentation reflects good research, whether it is presented well, and whether it contains significant new ideas. The ability to listen to and critically evaluate a presentation is useful in acquiring new ideas and in deciding what information is valuable. It is also good for discovering strengths and weaknesses or flaws in the content of your own research or that of others.

13.1.4 Presentations Improve Your Ability to Communicate

Education and scientific progress are so closely allied with personal communication that everyone involved needs to develop an ability to communicate well. Good speakers do not become effective without conscious effort. Put forth your best effort when you give a presentation and critically observe the efforts of your colleagues. The experience you gain will be well worth the effort when you deliver a presentation at a professional meeting or a job interview as well as for less formal communication efforts.

13.2 THE PROFESSIONAL MEETING

Communication at scientific meetings occurs through both the spoken word and visual language used formally and informally. The best information from meetings often comes from casual conversations. More formally, the speaker is a valuable part of the poster or oral presentation. When you are talking about science and research, you need to maintain your professional presence whether you are in a formal or an informal situation.

Prepare for more than just an oral or poster presentation. The importance of chance encounters and casual conversations should not be underestimated, and some preparation can be made for these exchanges. Good impromptu communication requires that you know your own material and the literature on the subject. Know how your research was planned, designed, and carried out; how data were collected and analyzed; and how your results compare with those of others who have done similar research. Prepare for informal discussions by going over your material before you get to the meeting, and take notes with you. Try to predict what questions might be asked about your work. Whether you are a graduate student or a seasoned scientist, to get the most from a professional meeting, plan ahead for situations you may encounter. Consider the points presented in Box 13.1.

13.2.1 Presentations at Professional Meetings

Relative to your career, the highlight of the professional meeting for you is your oral or poster presentation. Both of these formats are prominent at meetings in the sciences, and both require your communication skills. You will often be required to make the decision on whether to present a poster or make an oral presentation. You need experience with both. In many ways, except for format, both are similar relative to purpose and speaking skills. Consider characteristics and requirements for both and choose on the basis of which best fits your material and your ability. The comparisons and contrasts in Table 13.1 may be helpful.

As you are preparing your presentation, read Jay Lehr's editorial, reproduced in Appendix 14, to help you keep your audience's welfare in mind.

BOX 13.1 Getting the Most from a Professional Meeting

- Study the program that is usually published well before the meeting to roughly plan your own schedule.
- Plan to give an oral or poster presentation. If you are a student, enter a contest if one is held.
- Carefully select other presentations to attend, especially those by authors whose publications you have read.
- Unobtrusively critique the good and bad points in posters and slide presentations to help overcome your own weaknesses by applying new ideas to your own research and communication.
- Observe the leaders of your profession and how they conduct the meeting.
- Visit any placement or career services offered and talk with possible employers. You may be practicing for an interview.
- Meet as many new people as you can. Join informal discussions about your research and that of others. Plan to follow up with them later with a note or e-mail message.
- Schedule time to relax and enjoy highlights of the town with your friends and new acquaintances.

You must coordinate the subject and your visual aids with the audience as you present your work whether to a full audience or a single poster observer. Remember that most of the people in your audience will know less than you do about your subject. Prepare your talk or poster for these people. Try to develop the clearest and most effective way to explain the subject to them. If you aim your presentation at the few people in the audience who know as much or more than you about the subject, you may succeed in convincing them that you understand your material, but likely those few will not be impressed if you obscure the real significance of your subject from most of your audience with jargon and poor speaking or poor visuals.

Even with your own research peers, limit the use of statistical and technical jargon, but indicate what statistical analyses have been applied to your data and be able to explain them to any individual who asks. In most scientific research, statistical techniques are used only to provide a test of significance or to obtain an empirical mathematical expression of relationships. Emphasize the fundamental scientific concepts, not the statistical techniques. If you must use jargon terms peculiar to your subject, define them clearly or be sure your audience understands.

Try to orient your talk or poster around **one central idea**. Accept the fact that everyone in your audience will forget most of what you say, but if you do your job well, most of the audience will remember you and your point of emphasis for at least a few days, and those working in your area will remember far longer. If you fail to distinguish between major points and minor ones, your audience will not make that distinction for you. An audience will simply

TABLE 13.1 Comparison of Characteristics and Requirements for Oral and Poster Presentations

Poster presentations	Oral presentations
The Situation	
Relatively informal; contact one to one or one to few	More formal; contact one to many
Both speaker and audience standing	Speaker standing and audience seated
No moderator; direct contact, no buffer between the speaker and audience	Moderator helps to introduce, buffer the audience, and watch time
Time limit somewhat flexible	Time limit formalized
Audience free; only truly interested remain	Audience somewhat captured; most not likely to leave
Chiefly question–answer or conversational discussion	Chiefly information from speaker with a short question session
Handouts helpful; easy to exchange names and addresses	Handouts possible; less likely to exchange names and addresses
Preparation	
Prepare poster and materials for posting materials	Prepare slides and notes; plan backup
Know your subject—be able to justify objectives, refer to literature, and support your methods and results	Know your subject—be able to justify objectives, refer to literature, and support your methods and results
Prepare answers to likely questions	Prepare formal speech and visual aids
Get ready early; construct poster, review, and revise	Get ready early; practice, review, and revise

walk away from a confusing poster and a confused author. The speech audience may sit in their seats as a matter of courtesy, but their minds will have turned to more interesting subjects. Also, keep in mind that it is likely that few are obliged to be there, and they are present because they are interested in what you have to say. Present your objectives and results vividly. Restrict the scope of your subject so that you can give a thorough explanation of the essential points. Do not try to present too much information. Practice your material so that you are sure to finish on time and not too early or too late.

For clear communication, you must be conscious of symbolic communication and communication without words (see Chapter 14). Your attitude, facial expressions, tone, and all the symbolic displays in your slides or poster may carry stronger messages than anything you say. Visual aids, properly prepared

and used, can enhance presentations. At their best, however, visual aids are merely aids. At their worst, they can completely destroy the effectiveness of your presentation. They do not substitute for adequate preparation and effective verbal exposition by the speaker. For the poster, they should support and illustrate the written material and your comments or responses to questions from viewers. For slide presentations, consider yourself and your speech content, not your visual aids, the central focus of the presentation.

13.3 SPEAKING AT THE JOB INTERVIEW

You are even more specifically the central focus when you make a speech at a job interview. Taking a presentation to a job interview may feel somewhat more frightening than making other presentations, but it need not be. If you have taken every advantage of experience in academic seminars and at professional meetings, you should have built the confidence that can make you a good speaker. Take that confidence with you to the interview.

For the speech at the job interview, two points deserve special attention and are unique for this situation: the **audience** and the **purpose** of the speech. For your academic seminar, your audience is made up mostly of people you know, and many of them know what kind of research you have been doing. You are usually given enough time to fully explain your points. At the professional meeting, your audience is a group of people especially interested in your topic; they probably already know much about it. Your time is short, but they do not need a great many details to understand the point you want to make. Most of them are more interested in your research than in you. The same is not true with the job interview.

The audience at the job interview is often made up of administrators, managers, and scientists with diverse backgrounds who are interested primarily in finding out more about your research but also more about you, especially about your communication skills. Few or none of them may have any expertise in your specific area of research. You must present your material so that it is clearly understood by individuals who are uninformed about your subject. Because the audience is different from those at seminars and professional meetings, do not expect to make the same presentation to them that you have used for the other occasions. You need to revise a presentation every time you present it to a new audience, especially when a job is at stake.

Because the audience's chief interest is you, you must align the purpose of your talk with this specific characteristic of the semantic environment. Prospective employers usually have several qualified applicants. They want to know whether to hire *you*, whether you have done quality work in the past, whether you will work well with them, and whether your personality and expertise fit the position they need to fill. They want to know whether they will enjoy a professional association with you. Your purpose then is to provide positive answers to such questions. To do so, simply follow the principles for

all good presentations, but alter your own approach to accommodate the different purpose.

Give your audience the opportunity to discover more about you than is evident in a research presentation. For example, after you are introduced, it is a good idea to leave the lights on for approximately 1 minute, thank the audience for inviting you, and give a brief but not overly zealous explanation of your interest in the job. Then with a smile and a transitional remark such as, "My interest in this kind of work has increased with my research on …. Today I'd like to show you one part of that research in which …." At that point, you are ready to begin your presentation. This brief interlude between your being introduced and your presentation can put the concentration on you and can add immeasurably to the audience contact.

As with any presentation, maintain good eye contact throughout the talk. Time the speech to fit whatever time has been provided for you. If you have not been given a definite length, keep the speech short, no more than 20–30 minutes; explain fully a limited number of points; and relate your study to that of other researchers. Some of them may be in your audience. Establish credibility with your experimental design and analyses, and report results for which you have strong evidence. Discuss possible meanings or applications for the results, and project both confidence and humility. This is not the time for you to speculate on momentous breakthroughs that you believe you have made in science. Your audience may take that suggestion as a challenge to ask you some very difficult questions. Just take pride in what you have done, show the audience an example of your best work, and invite questions so that you can provide answers that will establish your expertise. Your attitude should be that of any good speaker—confidence flavored with a good dash of humility.

Limit the amount of material you present. The mistake I see made most often at professional meetings and especially at job interviews is that scientists seem to believe that they must display all the data they have ever collected and analyzed over several years. Be selective; present only a limited but critical part of your study. A few years ago, I watched a former student of mine interview for a position. He was given 30 minutes for his talk, and he unwisely decided to present work that he had done during the several years since he had received his doctoral degree, plus a segment on different work he had done for the doctorate, and then still another subject from the data collected during his master's degree. When I asked him why he had presented so many studies, he said that he believed the audience would be more impressed with the amount of work he had done than with the details. I disagreed. The audience can assume that he has done a great deal of work in earning two degrees and holding a responsible position for 3 years thereafter. What they cannot do is digest three complex studies in 30 minutes. The speech had loose organization to accommodate all three studies, it ran beyond 30 minutes, and there was not time to demonstrate credibility with details and show quality research. The young man was not offered the position. Audiences are accustomed to time limitations. Establish your credibility, present

quality methods and results, and show the relationship between your work and that of others. The audience can then readily assume that you have done other work of the same caliber.

Do not be surprised if, after your talk, the listeners seem rather uninterested in your research and ask questions that have little or no relationship to what you have been talking about. Remember that their concentration may be on you and not so much on your research. For them, your talk serves as a critical demonstration of what you can do and of how articulate you are. They already have a resume, transcripts, and letters that reveal your experience and abilities. They are now evaluating your personality. Recognize that point and deal with it positively before, during, and after your talk.

One last word on presentations at job interviews: Do your homework. Learn all you can about the position, the location, and the people in your audience before you get to the interview. Information on the Internet or at the library can tell you about a company or university or agency to which you are applying. Often, asking questions of the person who has invited you to come for the interview or the secretary who answers the phone can help you to understand the semantic and political environment in which you will be interviewing and making your presentation. Any networking that you have done at professional conferences can be beneficial here. Your major professor or other advisors can also be helpful in providing background information and preparing you to go to the job interview. They may know some of the personnel you will be talking with. Your knowing what kind of research is being carried out, even if it is unrelated to yours, and your knowledge of the work that particular scientists there are doing can influence whether you are offered a job. But paramount to all this background knowledge are your own communication skills; present your best.

13.4 THE QUESTION AND ANSWER SESSION

In any formal presentation, your interactions with the audience are crucial to your success. Those interactions are most displayed during the question–answer session. The question–answer session allows the audience to clarify points or add to their knowledge of your subject and find out more about you. It can build your reputation as a scientist and speaker, and it provides you with an opportunity to surmise the strengths and weaknesses in both your research and your delivery by the kinds of questions asked and your ability to answer them. You must keep the entire audience in mind during the question–answer session. Preparation for the session requires that you know your subject and maintain your confidence.

Give clear, concise, and respectful answers. Do not dismiss any question without a response, but do not belabor any point. Any question is important, even if it sounds trivial. Do not allow yourself to be pulled into a controversy. You probably know your subject better than most of the people listening, but the time and place are completely wrong for any heated disagreements. After

the presentation, you may want to continue a discussion with an individual, but do so only after you have released the audience.

Unless you have invited interruptions, most people will not interrupt you or ask questions during your talk; but if someone does, do not panic. Answer his or her question or respond to a remark courteously and completely but as briefly as you can. Keep your place in your own presentation and return to your prepared speech as quickly and smoothly as possible.

Most important, maintain a professional attitude throughout the question–answer session. Many speakers tend to lose their professional demeanor when the last note on their conclusions dies down. They may loosen a tie or lean on a podium and relax their diction too much. "Yeah" is not a good way to begin the answer to a question. Try "yes" or "certainly" or some other alternative. Avoid these distractions and maintain your role as speaker. If possible, let the moderator make the transition between your speech and the question–answer session. This technique gives the speaker a chance to relax momentarily. Meredith (2010) has especially good suggestions for dealing with questions, and Anholt (2006) provides some good information. The following suggestions may also help you:

1. Listen closely. You cannot answer well without hearing and understanding the question. Do not interrupt before the question is completed, even when you know what is being asked.
2. Repeat the question aloud if there is an even remote chance that it was not heard or is not clear to you or the audience. This repetition also gives you time to think and formulate your answer.
3. Pause. There is nothing wrong with taking 2 or 3 seconds to think, and your answer will probably be better for it.
4. Answer the question completely but as briefly and directly as possible. Do not go into a new speech. Others may also have questions.
5. Take questions from various parts of the room. If the same person keeps asking questions or wants to discuss an issue beyond a reasonable answer, suggest to him or her that you meet to discuss the matter further after the session.
6. Maintain eye contact most of the time with all the audience, not just the person asking a question. An individual is asking, but your answer goes to all.
7. Do not be afraid to say you do not know. Questions may be asked that are only remotely related to your subject. Simply indicate that your research has not supplied an answer to the question. Refer to the literature if you know a source for an answer, but do not guess. Never try to bluff an audience.
8. Reply courteously to all and do not become defensive. Accept statements and "loaded" or trivial questions, and maintain your professional composure. You can often dignify a question or comment that was not presented

with dignity by supplying a serious, professional reply that is related to the subject.

9. Always maintain your dignity. Anger is the easiest way to lose it. The audience will have increased respect for you if you reply to the hostile question with a smile and a serious answer.
10. Do not speak beyond your time limit. End the questions if the moderator does not do so, and make a final summarizing statement if possible.

13.5 ROLE OF THE MODERATOR

Whether the occasion is a departmental seminar, a speech at a professional meeting, a job interview, or some other speaking situation, the speaker may need to coordinate efforts with other speakers, a program coordinator, equipment operator, and especially a host or moderator. The speaker should arrive at a meeting early and meet the moderator and others who are in charge of the session. If several speakers are on the program, the moderator or technician operating equipment may need to know who you are and when your speech is scheduled so that he or she can put it in sequence. Let the moderator have any information he or she needs to introduce you, and be sure to coordinate your efforts relative to lights, time signals, and the request for questions.

On the other hand, you may someday be the moderator and chair an entire session at a professional meeting. Be sure that you can pronounce the names of presenters and the words in their titles. Your job is to introduce them, help them feel comfortable, and solve or buffer problems that arise. In chairing a session, you should provide transitions from one presentation to the next, and be sure that you keep everyone on schedule so that one speaker does not encroach upon the time of another.

13.5.1 To Be a Moderator

1. Obtain copies of abstracts or information about the talks you are moderating and familiarize yourself with each topic. Prepare a few relevant questions for the speaker to get the discussion started if the audience does not.
2. Help the speakers in arranging visual aids or needed equipment. The moderator should coordinate the operation of lights, projectors, and other equipment with the speaker and should be present in plenty of time before the session to assist with last-minute details.
3. Contact each speaker well in advance if possible. Talk with him or her and prepare a short introduction of the speaker and his or her topic. This introduction will probably include the following:
   a. Speaker's name and title
   b. Academic and professional background
   c. Any special distinction
   d. Title of presentation.

At professional meetings, do not use up the speaker's time with more introductory information than is needed.

4. Keep up with time. For example, with 15 minutes provided, we might expect the speaker to talk for 12 (plus or minus 1 minute) and answer questions for 3 minutes. The moderator must be responsible for keeping everyone on schedule—that is, see that speakers start on time and finish on time. It is better to interrupt a long-winded speaker than to encroach upon someone else's time. Be sure the speaker understands whatever signals you plan to use.
5. Be sensitive to problems the speaker may have. Check equipment and know where replacement materials are located. Coordinate all efforts with the speaker. Buffer him or her from a hostile question or a string of questions that do not allow the speaker to move on.
6. Accomplish all your responsibilities in a congenial and professional manner. The speaker is the star, but you are the host.

13.6 FIT THE OCCASION

Scientific presentations can take numerous forms other than those described here for seminars, professional meetings, and job interviews. In these situations, as well as presentations to groups such as public schoolchildren or civic clubs or even colleagues with whom you work, you may make a speech without visual aids, provide a demonstration of a scientific reaction, host a video or film presentation, or serve as moderator for a symposium or a group discussion. Equipment may dictate the kind of visual aids that you use. Be sure to find out what equipment is available or what you must take with you, and be ready for any problems that might arise with such equipment. Always have a backup plan. Plan B has seen many people through difficult situations. Adapt to the situation, but keep basic principles of clear communication in mind as you make use of new situations and alternative media or equipment.

In the following chapters, you will find more specific information on visual, verbal, and symbolic communication used in speech making, oral and poster presentations, and group communications. Most of the decisions on how best to communicate rest with you, but knowing the expected conventions can serve you well in making these decisions. Communication is a personal and a social activity as well as sometimes a professional one. Be creative, but rely also on standards or conventions that everyone uses. In other words, be yourself and use techniques that serve your personality best, but satisfy the expectations of your audience by using conventions that they will understand.

In addition to Lehr's admonitions (see Appendix 14), Anholt (2006), Booth (1998), Peters (1997), and Tierney (1996) have very good suggestions for making oral presentations. Briscoe (1996), Woolsey (1989), Anholt (2006), and Knisely (2002) cover the basic conventions for presenting posters. You can also find information on the Internet. Those sources, as well as this one, reflect

the personalities of their authors and may not always be in agreement with each other or with you, but the principles of communication remain the same. Consider the audience, the subject, the purpose, and the format, and present information in the simplest, clearest way possible with your own personality and abilities.

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Chapter 14

Communication without Words

It is the province of knowledge to speak, and it is the privilege of wisdom to listen.
—Oliver Wendell Holmes

Hall and Hall (1990) wrote that "90% or more of all communication is conveyed by means other than language, in a culture's nonverbal messages." The percentage of nonverbal language is extremely high in scientific communication. Certainly with any communication effort, we must recognize the transfer of information without, or in addition to, the words we use. All these elements influence the semantic environment. Listening and reading constitute much of communication, but we also comprehend meanings with sight and touch. In speech, every gesture and every facial expression add dimension to what we say. With written and visual media, we also use language beyond the words. Technical editors are trained to use typefaces and fonts as well as other symbols for emphasis to guide readers through a text. As authors design manuscripts for paper or electronic publication, they become responsible for symbolic language that used to be in the domain of the editor. Symbols, spacing, colors, and other embellishments can be as important as words in written and visual communication. In speech, the physical circumstances, body language, and listening habits all contribute to success or failure of information exchange.

14.1 SYMBOLS

Conventional symbols are available, and new ones can be designed to help us express our organization of ideas and the precise meanings of terms. Conventional symbols for organization include placement and size of headings that constitute guideposts to lead a reader from one section of a paper to another. Still common is the paragraph indention. Although paragraphs today are often not indented, this small space can help the reader move from one idea to another, especially if additional line spacing is not used between paragraphs. I contend that this transitional symbol should not be lost. We accept many symbolic conventions often without even noticing them. We stop at a period as we

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stop at a red light without consciously analyzing why. A great deal of simplicity in communication would be made complex if such symbols were not universally accepted in a language. Words themselves are actually symbols for sounds and meanings, and other symbols add dimensions to these meanings. We have become accustomed to italics to denote scientific names of species and abbreviations to designate units of measure. With careful use of such symbols, the audience will likely interpret them as you intend them.

Dreyfuss' (1984) *Symbol Sourcebook* is based on a data bank of more than 20,000 symbols. Such symbols supplement all languages. Some, such as the skull and crossbones image that indicates "poison," are recognized worldwide; others are limited to a small group of people or perhaps to specialists in a given academic discipline. Sign language, Morse code, chemical structures, braille, traffic signs, and thousands of other symbols all carry important messages. Common symbols many of us see every day are the icons on our computers; communicating via the computer requires that we recognize their meanings. Symbols are handy tools for language if both the sender and the receiver of a message interpret them in the same way.

Size, shape, spacing, color, and location as well as underlines and bold print can be used with discretion to help organize, emphasize, and clarify meanings in your writing or in visual displays for posters and slides. Without discretion, such symbols can simply confuse an audience. If every third word in a text is underlined, the underlining has no meaning beyond counting words, but if only one word in a paragraph is underlined, the reader interprets the symbol as suggesting emphasis. The use of large print, boldface, color, total capitals, white space, and positioning all call attention to a spot or a word. For example, a heading set in 14-point type, in total capitals, in boldface or italics, centered or underlined over an indented paragraph in 10-point type indicates that the heading denotes the subject of that paragraph. Such spacing and size help readers to move from one topic to another. If such a note followed the paragraph or was buried within it, not only would it lack the intended meaning but also it would confuse our thinking by interrupting the conventional and logical arrangement of ideas.

All these points seem obvious, but prudent use of symbols can facilitate understanding, and confusion can originate from careless or imprecise use that might create false emphasis or ambiguity. For example, if you label items in a list as 1, 2, 3, 4, the reader may assume that 1 is more important than 2. Designating items with a, b, c, d may be less likely to draw that assumption, and using a consistent bullet or shape such as * in front of each item is even less likely to suggest that the first item is most important. However, you may need to tell your audience that "the following items are of equal importance" or "… are listed in order of importance."

Spacing and positioning of text and images can add to or distract from the intended meaning, but too many symbols used together are counterproductive or what Keyes (1993) refers to as "perceptual overload." Clarity and simplicity

are the principles that should be applied to nonverbal signals as well as verbal and structural elements in communication.

The overall appearance of the page or visual aid conveys a message even before the audience has read a word. Increasing the widths of margins to place a section of text inside the main text indicates that you are quoting another source of information or presenting an example or a subordinate point. Successive indentions may indicate less importance or a dependence of the material with the deeper indention upon that above it. The same is true of a smaller font placed against a larger one, and thick lines are more emphatic than thin lines. The possibilities are almost limitless for combinations of spacing, underlining, boldface, styles of letters, and other elements of emphasis.

Many symbols are standard and generally carry a fixed meaning, but one must be careful in the use of others. Just as the same words can be interpreted in more than one way, so can symbols carry different or ambiguous meanings. Electricians can be confident that the colors of the wires they work with symbolize the same meaning from one job to the next, but as Imhof (2007) declares, colors can be ambiguous, especially between two cultures. Royalty may be represented in one culture by purple and by yellow in another; some symbolize death with black, others with white. Body language can carry different meanings. Lack of eye contact between individuals may represent respect with one culture, and direct eye contact represents respect in another. Shaking the head side to side may be "No" to one and agreement to another. Hand gestures are extremely symbolic but again can carry quite different meaning between cultures. To avoid misunderstanding, try to understand the meaning of any symbols or words you use in the context of the semantic environment in which you are communicating.

14.2 FONTS

Especially with word processing and constructing posters and visual aids for presentations, you need to understand something about font sizes and styles. Printers have various styles of letters that they refer to as "faces." We select a **font**, which consists of a size and face of type. Faces have names such as Times New Roman, Arial, Script, and Old English. Size is measured in units called "points." What you are reading now is 10-point Times type; the title for this chapter is in 22-point Optima-DemiBold. Another printer term that you may need to know is serif. A serif is an extension beyond the main body or shape of the letter. The small horizontal extensions at the bottoms or tops of letters like l or h in Times New Roman are serifs. Type called "sans serif" is blocky without these tails or extensions.

This text is sans-serif, 12-point Arial bold.
This text is serif, 12-point Times New Roman bold.

Because of the different lengths of the names of the typefaces and the compactness of letters, the previous two examples take up different space

horizontally. Notice that the Arial seems to have thicker, wider letters but is more compact. Both are 12-point type. The vertical height in both lines is the same; it is this height that determines the point. Typefaces and sizes can be important when you choose a font for a manuscript or a poster or slide. Some are easier to read than others. Be conscious of type styles and sizes when preparing a paper for publication or reproduction by electronic transfer. A scientific poster or slide can also be much clearer if the text is in a large, easy-to-read font. **Keep in mind that lowercase letters with only the grammatically necessary capitals are easier and faster to read than total capitals.** See other examples of fonts in Chapter 17 on posters (Table 17.1).

14.3 COLOR

A great deal of variety can be accomplished without color by using other non-verbal elements in communication. Color simply adds another dimension to communication. We are so accustomed to dark type on a pale background (black on white) that this pairing generally evokes little response from the reader beyond the meanings of the words themselves if the font is consistent. But insert a bright red word, and the symbolic meanings with color can elicit a complex and sometimes even an emotional response. You have probably reacted with some sort of pleasure or disappointment to a red note on a paper that a teacher has graded. Scientific analyses of color do not take into account the emotional response a viewer may have to color. As Imhof (2007) says, "The concept of color is ambiguous." Because of the ambiguity in reactions of individuals and groups from different cultures, one can hardly provide a set standard for communicating with color, yet it is an important element especially in scientific presentations and posters. As with other tools in communication, we need to understand basic conventions or expectations that are acceptable to an audience.

Imhof's (2007) theory of color (see Appendix 12) provides a valuable guide for cartographers that we can apply to other scientific communications. He maintains that "A color in itself is neither beautiful nor ugly. It exists only in connection with the object or sense to which it belongs and only in interplay with its environment." Thus, shiny red means one thing on an apple, it means another on a football jersey, and it means still another on an exam a teacher has just returned to you. In addition to the effect of semantic environment on meaning for color, one's own personality, past experience, or the culture in which he or she lives may give to a color a particular meaning in a given context. Dreyfuss (1984) notes that each color has both positive and negative associations in various situations and cultures. People call colors harmonious or clashing. We speak of cold colors and hot colors. Blue is cool or cold; yellow is warm or hot. There are hot pink and cool green, earth colors in shades of brown and orange, and neutral gray that some call drab and others beautiful.

Tenner (1996) suggests that "the eye can distinguish more shades of gray than of any other color." And in a feature in *The Wall Street Journal*

(November 17, 1993), Laura Hays noted that the medical community finds "gray and scales of white to black as the safest and most practical color choice for digital images." Imhof (2007) says that "gray is regarded in painting to be one of the prettiest, most important and most versatile of colors. Strong muted colors, mixed with gray, provide the best background for the colored theme." This remark from a color expert may provide an important message for us when we choose background colors for posters or slides. Appendix 12 provides more of Imhof's discussion about color.

These opinions about gray do not mean that we simply use black and white and shades of gray for all our communication. Alone, gray can be beautiful, but probably its leading role is to mix with other colors to subdue the tone. Brown can also subdue the brightness of some colors well. If we look around us, we can see color preferences for cool, subdued backgrounds that humans generally seem to prefer to live with day to day. Drive down almost any street and you will see that houses are typically not bright, hot colors but, rather, white or off-white, grays, tan, or brown tones. Even what are called red or yellow brick homes are more brown than red or yellow. And typically, the walls inside those homes are not bright but, rather, subdued colors. Look across a parking lot and note how many of the cars are either black or white or any number of subdued colors—grays, blues, greens, browns, reds—but you see few that are bright yellow, bright red, bright blue, or bright green. Surely we can conclude along with Imhof that people prefer background colors that are subdued with gray or brown. If your car is the bright yellow one, that is fine; it reflects your personality. But in communication of science, consider the audience's typical preference as well as your own. Use subdued colors for backgrounds of slides, posters, and illustrations.

Care with the use of color is important in scientific communication. As Tenner (1996) notes, the prominence of some colors can be deceptive, and in her *Wall Street Journal* feature, Hays says, "Certain colors can look bigger or smaller in the same-sized area." Dreyfuss (1984) says that "color produces immediate reaction and is the exclamation point of graphic symbols, so it must be reckoned with." He goes on to declare that "one's attention is often captured by color before form or composition is completely distinct." With color's ability to attract, it **does matter** what colors the scientist selects for communicating an idea. Colors have meanings that can either support or deter the meaning of the scientific point you wish to make. For color selection, we rely on the natural environment for some meanings and on established customs in a culture for others. Hot pink would seldom be selected over a cool blue to indicate a geographical body of water or even as a background color for scientific slides.

The meanings of colors may be associated with safety. Electricians communicate with colored wires, and highway departments communicate important issues with color. In the United States, stop signs are red, caution signs are yellow, and information signs along highways are green. Without words, we have established that for traffic lights red means stop, yellow is a caution, and

green means go. Their positions are top to bottom, respectively. When you use color to convey meaning, be sure to remember your color-blind colleagues. To them, the top traffic light means stop and the bottom one means go. Position, spacing, size, or design may carry your message as well as color in such things as graphs and will not leave out this audience.

Computers can produce millions of variations in colors; such technology is far beyond the simplicity needed in scientific communication. Humans can hardly distinguish that many shades of color. Do not ever let color or any other symbolic ornamentation distract from the scientific message. Too many colors, large areas of strong or bright colors, inconsistent use of colors to represent the same meaning, or poor choice of color can be detrimental to communication. Selections for combinations of colors can be important for slides and posters. For example, red text may contrast well and be quite readable on a white slide, but it may not be clear against a blue one. If dark, subdued backgrounds are chosen for slides, the text should probably be a soft clear, light color such as a not-too-bright yellow or white.

As with the meanings of words, the scientist must select a color that is aesthetically pleasing but will not distract from the science by calling attention to itself. Ask for the opinion of reviewers before you make final decisions on colors to use. Imhof (2007) says, “Subdued colors are more pleasing than pure colors.” He goes on to provide six rules applicable for map design that may be equally applicable for other scientific presentations. I strongly recommend that you read Imhof’s chapter “The Theory of Color” (partially reproduced here in Appendix 12), and when you are making graphs or other illustrations, consult Briscoe (1996), Tufte (2001), and *Illustrating Science* (Council of Biology Editors, 1988) for details on communicating with design as well as color.

14.4 PHYSICAL COMMUNICATION

In spoken communication, the physical setting in which you talk, your physical presence, and your body language are all a part of the semantic environment and can be more important than any words you say. If you have control over the **setting**, make it as comfortable as possible for you and your audience. If you have no control, be conscious of such things as lighting, noise, temperature, the arrangement of chairs, or other attractions and distractions. Sometimes you will have to make decisions between the lesser of two evils; for example, choosing between a comfortable temperature and a noisy furnace or fan is not easy. Your words are worthless if your audience cannot hear them or are too distracted by other elements in the environment.

The value of your words is also enhanced or diminished by your own physical presence and your **body language**. As Smith (1984) says, you “are your most important visual” aid. You can also be your own greatest distraction. Every movement you make, small or large, contributes to your communication. You talk with your eyes, with your feet, with your posture, as well

as with your hands. Your grooming is one of the first messages you present to your audience. It is idealistic to suppose that the audience will "pay attention to what I have to say, not how I look." What you should wear depends on what your audience expects. The way you style your hair is certainly your business, but it can still convey a message. Be attentive to your grooming. Styles do change, but conventions in clothing and appearance are relatively stable in the scientific community. Your grooming and body language reflect a tone or attitude that cannot be hidden behind words.

Physical expressions are as important as grooming; many expressions are extensions of your personality. You do not change your personality for an audience, but you can condition much of your body language within the confines of your personality. Often, we are not conscious of our own mannerisms. One student had a habit of unwittingly batting his eyes as he spoke, and in making speeches for my scientific presentations class, the constant blinking was most distracting. We were able to call his attention to the habit, and with conscious effort he controlled it and was a much better speaker with that single change in body language. The focal positioning of your eyes carries important meaning. In the United States, contact between the eyes of the speaker and those of the audience is expected to help convey a message. But you can also say things with your feet or your hands, a shrug of the shoulders, or a wave of the arm. Other cultures do not always give the same meanings that Americans do to specific gestures or other body language, especially language with the hands and eyes. Chapter 20 provides further discussion of differences in body language between cultures.

You may inadvertently emit meaningless, distracting vocal sounds that clutter your message. Grunts, "ums," "ahs," and "you knows," a constant clearing of your throat, sniffing, or other audible distractions can cloud your message. Some of us do not have the most beautiful voices in the world, and a physical condition such as swollen adenoids or a cold may make it essential that we clear our throats, sniffle, or blow, but control these things as much as possible.

Such control may not always be possible. Do not despair if you have a speech impediment or a physical condition that attracts attention to itself but is out of your control. One of the most successful people I ever knew stuttered—not just an occasional repeat of an explosive *B* but repeated interruptions with stuttering over words or letters. He never allowed this condition to interfere with a career that demanded public speaking and group communication. When his voice would hang onto a letter, he simply allowed the stutter to run its course, took control again with no apologies to anyone, and moved on with his speech. Audiences respected him. The first-time listener might be momentarily taken aback, but in almost no time that person was listening to what was being said and, along with the speaker, was essentially ignoring the stutter. If this speaker had exhibited added nervousness or an embarrassing self-consciousness, the audience would also hang onto the impediment and

lose much of the speech content. By example, the speaker simply guides the audience in how to react. If you have an uncontrollable voice problem, a physical deformity, or even a temporary bandage on your face or hands, you need not try to hide the appearance nor call attention to it by apologizing or appearing embarrassed. Almost everyone has some sort of problem. Whether you are extremely beautiful, tall, short, thin, fat, or have to walk with hand crutches or sit in a wheelchair, an audience will notice. Accept that fact, and make your listeners as comfortable as possible by not calling attention to whatever it is that makes you different. Whenever you can, control your appearance as well as the physical situation. For a scientific presentation, never make a point of attracting attention to your appearance rather than your message.

Features of your voice as well as body language can have a positive effect on what you have to say. Voice inflections, volume, and tone can change the entire meaning of words or make a point more or less emphatic. Practice to make your voice quality help to carry your message and coordinate the voice with the body language. With tone, volume, or emphasis in your voice, a hand gesture, closed fist, open palm, or directional movement of the hand can help to clarify meaning. Facial expressions with tone can indicate beyond the words whether you are serious or jesting and whether you believe in what you are saying. Ironically, clever use of body language along with meaningless jargon can sometimes make an audience believe you have said something important whether your words are meaningful or not. Perhaps politicians and salespersons often depend on this ability. As a scientist, you should not mislead audiences to believe what you say is important when it is not, but spoken communication is made most effective with use of physical expressions to reinforce the words.

Position, posture, and space are also important in communication. Where you stand, how confident and erect you stand, and how close you stand to an individual or to an audience convey messages. Humans are territorial; to get too close may invade their space, especially between individuals. However, a step forward toward a group suggests bringing the message closer or including them more fully. We often move a step or two toward an audience when we invite questions. To enhance the semantic environment further for audience questions, be sure the lights are turned on the audience as well as the speaker. These techniques suggest to the audience that they are involved and their questions are welcome. On the other hand, to leave the audience in the dark or in subdued lighting or to back up too far or to plant yourself too firmly like a speaking statue behind a podium is less inviting to the audience. Our convention of the speaker's stand or, perhaps better, simply of the speaker standing in front of a seated audience is important in relegating the speaker and listeners into their respective roles. The physical setting combined with the appropriate body language can produce a relaxed atmosphere for communication with an audience.

Your personality, cultural background, physical condition, needs, or beliefs can influence your mannerisms so that you are not conscious of your facial

expressions or body movement. Ask an observer to point out the strengths and weaknesses in your body language. Control the expressions that enhance your scientific message as well as those that distract. Do not let your meanings get lost among physical attractions or distractions.

14.5 LISTENING

Body language and voice, more than the words themselves, motivate an audience to listen or not to listen. We often underrate the importance of listening. Half of the responsibility for spoken communication should be that of the listener, but we design full courses for teaching speech and give little or no attention to teaching people to listen. Listening is a matter of hearing, observing, and thinking all at the same time in order to have the clearest perception possible of what a speaker is conveying. In your career, you will likely spend more time listening than speaking. Use this time wisely. Most of us have bad listening habits, but they can improve with practice.

Perception, or comprehension, not just hearing, is the end objective. In fact, the ears are only a part of listening. If the speaker is physically present, the listener's eyes must watch the speaker and be sensitive to his or her physical expressions as well as the words voiced. Also, be sure your brain is engaged with the ears and eyes in order to avoid misinterpreting what is said. Be selfish; remember that you receive more from listening than from talking. To listen well, one must be sensitive to all the elements in the communication. Pay attention.

It takes concentration and energy to listen well. As with other forms of communication, you have to maintain the right attitude. This attitude should be receptive, not defensive or patronizing. Many of us have expended a great deal of energy and concentration in our lives on appearing to listen when we are actually tuning things out. We had other things on our minds when parents or teachers were talking, but we developed an ability to hold the proper facial expression and look at the speaker while our minds wandered. Or rather than paying attention to what is really being said, our thoughts are planning a reply to what we think is being said. Just half listening or "listening with one ear" is as bad as mumbling or just half speaking. Listeners must do their part to make communication a success.

Listening in a small group in which ideas are being exchanged is probably the most difficult listening challenge. You must be able to change your focus quickly from one personality to another and synthesize or recognize relationships in the material from several points of view. Listening as a single receiver of information or as a member of an audience requires variations of the same good habits. A conscious effort on your part could lead to better listening. Try the following:

1. Look at the speaker. If you need to take notes, do not let that action make you miss the nonverbal communication.

2. Be sensitive to the tone and inflection in the voice. Watch how body language and voice blend into meaning.
3. Do not interrupt. A speaker may be struggling for words that you could easily supply, but let him or her finish an idea before you inject a response.
4. Be receptive and concentrate on meanings. Relate what the speaker is saying to what you already know and, thereby, increase your knowledge.
5. Tune out the distractions. No setting is perfect. There will be noise, poor lighting, something else on your mind, or another member of the audience making distracting sounds or movements. Focus on the speaker and not the distractions.
6. Watch your own attitude and try to empathize with the speaker. Be open-minded. Do not jump to conclusions or judge the speaker by his or her appearance or accent, and evaluate what is being said only after you have heard the entire speech.
7. Interrupt with a question only if that question cannot be postponed. When the speaker is finished, be sure you have understood meanings. Then, ask questions or paraphrase what was said to clarify any nebulous points.
8. Be sure to respond. In a small group or one-on-one conversation, you can use your facial expressions or other body language to indicate when or how you are interpreting what is being said. You can ask questions to lead the speaker toward clear explanation. When the speaker is finished, you can make your comments or observations. In a large audience, you may think your response is not important, but it is. Even if you cannot ask questions or make comments, your attention, posture, eye contact, and facial expressions are important to the speaker.
9. Be patient. You can hear much faster than the speaker can talk, but remember that listening requires more than just hearing. Use that extra time to think about what the speaker is saying and to make your nonverbal response.
10. Do not be distracted. It is demoralizing to a speaker to say, “Go ahead, I'm listening” when you are obviously being more attentive to someone or something else.

Listening, as well as the more tangible elements in communication without words, is crucial to clear understanding. Not just in visual displays but also with any written or spoken communication, the value Imhof (2007) gives to “the composition as a whole” is fitting. Your manuscript or your speech is not just organized words and ideas. It also contains symbolic images, whether they are created by typeface and font, color, physical circumstances, or body language. Concentration by the listener and the reader is also tantamount to successful communications. Pay close attention to your words and how they are organized, but also be conscious of the appearances and the listening habits of both you and your audience.

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Chapter 15

Visual Aids for Presentations

Blessed is the man, who, having nothing to say, abstains from giving us wordy evidence of the fact.

—George Eliot

As with other symbolic images, visual aids can complement or supplement words in both written and spoken texts. Their basic function is to clarify points beyond what the spoken or written word alone can do. In written documents, the photographs, drawings, and graphs as well as tables often carry the primary message. In any scientific communication, if visual displays attract attention only to themselves and do not increase clarity, they serve as distractions. Used effectively, they will strengthen the scientific message. Attention to the following five principles will help you avoid pitfalls in the use of all kinds of visual aids, especially in oral presentations:

1. Make them simple enough to be comprehended easily.
2. Make the images or letters large enough to be seen clearly.
3. Make a trial run long enough before an oral presentation to permit you to change the visual aids if they do not serve you properly.
4. Coordinate them carefully with the speech or text so that the audience is not distracted and the visual aid is relevant to the point of the message.
5. Just before a presentation that incorporates visual aids, be sure any needed equipment is in place and operating smoothly.

All sorts of visual aids can serve the scientist in speeches, demonstrations, teaching, and presenting displays such as posters. A visual aid may be any visual image, including speakers themselves, their personal appearance and body language (Smith, 1984), or such things as a live animal to show its anatomy or behavior, a complex physical model of a process, or a model of a molecular structure. Although electronic images projected on a screen, poster displays, and illustrations in books and journals are probably the most common visual aids for scientific communication, other forms are still valuable in many situations. Images on paper, white boards, chalkboards, flip charts, video displays, overhead transparencies, or the props themselves can serve to assist a speaker or writer in making a point. Take advantage of whatever visual display is available, feasible, and beneficial to your communication.

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The situation in which you use specific visual aids is important, and most of them require equipment whether it is chalk and a chalkboard, a computer, a white board, a projector, or a poster board. Recognize the values and limitations of each. Flip charts and posters accommodate small audiences and require well-lighted conditions. Slides need subdued lighting but can serve a rather large audience. Speakers often fail to note how handy a chalkboard or white board can be. You should not write lengthy messages on it because your back is turned to the audience for too long, but in answering a question, it is often helpful to quickly sketch a chemical structure or write an unusual word or short list for the audience to view. Videotapes interrupt the speaker entirely but can be coordinated with a speech if they are relevant. I attended a presentation once wherein the speaker introduced his subject, which had to do with the processes involved in germination and seedling emergence. After the introduction, with equipment ready to go at the push of a button, he showed a short time-lapse video of a soybean seed developing into an emerged seedling. He then provided a transitional remark and began his presentation of slides. The video was quite effective and did not distract from the speech or the subsequent slides. However, two media can be difficult to coordinate, and interruptions to the flow of the speech can be distracting; be sure they fit smoothly into your presentation. Objects for show-and-tell can also be valuable or distracting. Any such prop needs to be large enough for all the audience to see and yet not ostentatious enough to distract throughout a presentation. The size of the audience can be an issue. Generally, passing an object around the room is distracting; it may be better to invite the audience to stop by to view the display item after the speech. The important point with any visual device is to make it serve, not obstruct, the communication.

Visual aids can add information, illustrate or provide examples or evidence, or they may repeat what you are saying or writing. In the poster, you can present information via a graph or photograph, and the written text will just call attention to that information. Similarly, in a speech, you may describe the effect of a chemical compound on a petunia plant. Your words will be strengthened if you have pictures of a nontreated and a treated petunia to illustrate your point. In writing, you have been taught not to be wordy or redundant. In speaking, repetition used discreetly is often the best way to strengthen a point. A reader can return to a point in a text and read it again. Because a listening audience does not have the option to listen again, a judicious speaker will often reinforce with repetition. Visual aids can help you duplicate a point in a second medium without appearing redundant. Also, the speed with which you present an image is important. Speaking too quickly or flipping past an image before it has been digested by an audience not familiar with it can make the visual as well as the speech simply confusing.

Visual aids can also help compensate for language barriers. When your first language or your accent is not the same as that of your audience, the importance of supplemental aid increases. It is especially important that you display

key words you have trouble pronouncing or those that are new to the audience. With this assistance from your visual aids, if you will speak slowly and enunciate carefully, an attentive audience will understand you. I am not referring just to international students or to professionals from non-English-speaking countries. The English-speaking world includes numerous accents. Whether you are from Burundi, Bangkok, Boston, Baton Rouge, or Bath, your accent will be foreign to some of your audience. Along with being proud of the way you sound, be sure you provide any assistance that your audience may need for understanding you. The best advice I can give is **slow down** and provide informative visual aids.

As with other symbolic communication, the style, layout, color, type, and form for a visual image should be clear and aesthetically pleasing. Characteristics of symbolic media may be as important as other content in carrying messages to the audience. For example, color in a PowerPoint presentation or a poster can be a point of unity. Choose a template or customize basic colors and style with care, limit the number of colors used, and coordinate them carefully with each other and with the content of the speech. Subjects, ideas, or transitions can be coded by color. For example, if you use a series of bar charts, and in the first copper sulfate is represented with a blue bar, then copper sulfate should be represented with blue in any other image used. See further discussion of color in Chapter 14. In addition to color, other characteristics essential to the success of a visual aid include type, consistency, size, form, density, spacing, and style. Be creative but also use conventions the audience expects. Computers can provide many advantages in creating visual aids, but they can also produce complexities or outright errors. Use their capabilities carefully. In this and other chapters, I discuss primarily visual displays used in slide or poster presentations, but the same qualities are important for any visual aid you use in any paper or presentation.

15.1 SLIDE COMPOSITION

The use of electronic projection is now the norm. I suppose the word *slide* should not be applied to electronic projection, but it appears the word has been transferred to the electron images, and I use it to mean the image projected onto a screen from a slide projector or a computer. We have come a long way in our ability to make slides during the past 40 years from black-and-white reverse image photos to the use of colored gels to today's digital imagery. Many of you now probably do not even recognize what I am referring to and may even consider computer-designed 2 × 2" slides that sit in a carrousel as hopelessly old-fashioned. As with other developments in tools for communication from the pencil to the typewriter to the computer, this electronic medium is a valuable advancement. But with any tool, dangers accompany the advantages, and we must be mindful of the communication principles of clarity and simplicity in our use of any tool. For example, the ability to animate slides or embed a video

electronically offers a great advantage of presenting material in a sequence that simplifies and keeps audience attention on a single point or lets us build a flow chart or other image piece by piece to facilitate audience understanding. See the example in Appendix 13. On the other hand, presenting such information too rapidly or using animation that attracts attention to itself and not to the scientific point can be most distracting. Use any embellishment only to clarify an issue, not to distract.

In referring to slides, I refer to the software I am most familiar with, Microsoft PowerPoint, but I am not recommending it over any other that you may wish to use. Others may be as good or better; for your purposes, the principles remain the same. Any single visual aid should meet the following criteria:

1. Simplicity—Usually one point with limited subpoints
2. Visibility—Distinct and legible to any person in the audience
3. Unity—Cohesive and uniform with other visual aids and with the written or spoken words
4. Quality—Clear, attractive, and aesthetically pleasing
5. Feasibility—Possible with the materials, facilities, and time available.

Keep up with the tools that can be used, but they do change often, and this discussion primarily concerns the principles for good communication, not the tools used. Science is a serious matter. We can certainly be creative and add notes of humor to our presentations, but our communication is essentially to inform and teach. Enjoy the advantages of what technology can do, but when it comes to writing a paper and making a scientific presentation, do not let anything distract from the message.

With few exceptions, the scientific slide presentation will consist of word slides, photographs and other illustrations, and data display in figures and tables. A mix of these kinds of slides is more interesting than all of one. See Appendix 13. Photographs can provide information, transitions, and visual relief in a scientific slide set that has a great many word slides or tables and figures. As you pursue your research, keep a camera handy; images from a digital camera will be easy to put into an electronic slide set, or a scanner can serve to transfer prints to your set. You will one day need pictures of equipment, plants, animals, symptoms, or other images from your research for written, oral, and poster presentations. Some may be as important or more important than words. Microphotographs may be the most informative evidence in the results of a study on a science that is invisible to the naked eye. For a slide or poster presentation, color photos are usually best, but also keep in mind that you may wish to publish a picture with a journal article and that journal may publish only in black-and-white. Compile a file of photographs associated with your research project; they will be invaluable when you begin making slide sets and posters.

Courses in photography and numerous books for beginners are available. You can learn a great deal on your own. Use a camera that produces

high-quality images. Cell phone cameras are being improved, but many today still give less than adequate sharpness and detail for scientific subjects. Good photography takes some practice. Give yourself a short course by reading instructions packaged with a camera, ask questions of people at camera shops, and take pictures and study the results. As you take photographs, visualize the final product; the image is in your viewfinder. Then study the resulting photo. Be sure that the subject you want to display dominates the picture; some people take pictures too far away from their subject and include too much or distracting background. Certainly, background is important. The photograph will appear two-dimensional, and tree limbs may look as though they are growing from people's heads. Placing your subject against a solid background, the sky, the earth, or an improvised backdrop can help. Lighting is influential with both outdoor and indoor photography. Outside, the sun may be too bright, or it can cast heavy shadows that will subdue your subject. Be sure your subject is the area in focus.

Likely, most of your slides will not be photographs but text and images—for example, title slides, key words, and data in tables and figures. Whatever method you use for producing word slides, the resulting image will have relative dimensions of 2 units by 3 units. Try to keep the orientation horizontal; that is, the longer dimension will run across the screen. Balance the content on the screen with select words or symbols that are spaced appropriately and are clearly visible from anywhere in a large room when projected onto the screen.

Plan your slides for viewing in a large room, and you can use them in a small area as well. Generally, the smallest text on the slide should be no less than 20 point. Most of the text should be 24- to 40-point type with limited serif or sans serif, and titles and headings can be 40 point or greater. Some people recommend that we use serif type for printed text and sans serif for that viewed on a screen. That may be a good general rule. For slides, I suggest such typefaces as Helvetica, Ariel, Tahoma, or similar styles of san serif or Times New Roman if you like serif. Each slide should make one basic point, perhaps with a subpoint or two, and the text on the slide should cover no more than 14 lines (10 or fewer is better) including the blank lines between type. Lines should never be longer than 40 spaces (34 or fewer is better). Note the following:

Objectives

1. To compose attractive, legible visual aids.
2. To conserve both time and cost in slide production.

This example is composed of six lines vertically and the longest line contains 25 characters horizontally. It will fit the 2 by 3 format for slides, and the 16 words are not too many for an audience to comprehend quickly, especially if you direct their attention to each objective with a pointer or animate them into view one at a time and move over the slide slowly.

Fill the screen but not with too many words or ideas. Space is important in filling the slide to make for comfort and clarity. Text for word slides should be limited to key words and phrases, not lengthy sentences and paragraphs. The speaker should fill in the information needed about those key elements. Complex slides can be made more immediately comprehensible by breaking them down into individual points or parts so that an audience can follow the speaker through complex information. See the examples in Appendix 13 for designing a single word slide or for building a slide with a series of simpler parts (the house-that-Jack-built technique) as well as a full, effective slide set. Anholt (2006) has good descriptions and examples for simplifying complex slides.

In addition to spacing and sizes, in slide making be careful in combining colors or using a colored text on a colored background. For instance, a bright yellow may bleed into a blue background or cause a blurry whitish image at the interface. Use solid distinctive colors for such things as bars in bar charts, but choose them carefully so that one color does not appear more important than others. Make trial runs with various colors of backgrounds and text or bars and lines to provide model slides on which to base your color selection. Then use consistent colors for backgrounds and texts throughout a given slide set. Keep in mind that the light intensity on the projector will differ from that on your computer monitor, and the colors may not be the same when projected. Choosing dark subdued backgrounds and contrasting light colors for the text is a relatively safe choice if you cannot try out your slide set on the equipment you will use for your presentation. Some people believe black on white is the best contrast, but colors can be pleasant. Further comments on the use of color are in Chapter 14 and in Appendix 12.

These principles on size, spacing, and color are especially true for tables and figures. For a slide presentation on research, your data are the most important support to your objectives and conclusions. Present only the data points that are essential to your talk. More than 20 items in the field of a table are probably too many; fewer than 16 would be better. In a line graph, 3 lines are much better than 5, and more than 5 can be too many. In a bar chart, grouping can affect the number used. In groups of fours, 12 bars may be understandable; in groups of twos, 8 or 10 bars are acceptable; for single, separate bars, try to limit the number even more. Let exceptions to these standards be rare. Every added bar or line adds to the complexity for the audience. You may be able to divide tables that might be published as single tables into two or more by separating variables. If comparisons of these variables are needed, then use the house-that-Jack-built technique described in Appendix 13.

Although you would not do the same in a publication, often you can reduce the number of data points in tables and figures by recognizing that representative data will illustrate your points and you can verbally discuss any omissions. You need not present all values if you provide the audience clear spoken explanation; just be careful not to let the omission mislead them. If three different lines in a line graph run along similar data points, take two lines out and tell your audience that the data omitted are similar to those represented by the line on the slide (an example is shown in Appendix 10). Recognize that requirements for data presentation with a speaker there to explain are not the same as for publication. Readers can study a complex table or figure for as long as they like; viewers must comprehend the point immediately in order to pay attention to what the speaker is saying before the visual aid is gone. **Seldom can you simply transfer tables and figures from a publication to visual aids for a slide presentation or from the presentation to the manuscript for publication.**

Notice that the table shown in Box 15.1 could appear in a publication, but it should not be made into a slide for two reasons: (1) The type would be too small for an audience to read, and (2) if they could read it, it contains too many numbers for them to comprehend in the short time a slide should remain on the screen. To produce an acceptable slide, choose representative data that best illustrate the point you wish to make. For the table in Box 15.1, let us assume that you wish to emphasize differences in the total nitrogen. Note how Box 15.2 accomplishes this purpose and preserves an acceptable type size with the limited number of data points. As a speaker, you can point out any differences that you need to discuss relative to shoots and roots, or if you have time for the specific discussion on those points, you might produce two additional slides with that information. Three slides with limited information communicate better than one that is too heavy. The speaker also can provide the additional information that was in the original caption and footnote without putting it on the slide itself. Box 15.2 has no table number and no footnote. The number is superfluous in a spoken presentation, and the speaker can explain that the letters represent statistical significance. You may decide to reorganize your slide set or use the slide in another presentation, and the number on a table or figure might no longer be applicable. Notice that the same limited data from Box 15.2 can be displayed in graphic form as in Figure 15.1. Unless you need to present specific amounts, this visual image may be more effective than the table.

Some equipment allows for more flexibility than others, but you, not your equipment, are responsible for your slides. Make the equipment work for you. Note the following suggestions for composing word slides as well as tables and figures:

1. Use a thick, blocky type. Italics, script, or thin letters are more difficult to read.
2. Use lowercase letters, capitalizing only where grammatically necessary. Lowercase or the mix is easier to read than total capitals.

BOX 15.1 Table from a Thesis

TABLE 4. Influence of *Bradyrhizobium japonicum* USDA 110 (BR) and *Heterodera glycines* Race 3 (SCN) on Root, Shoot, and Total Nitrogen Contents of 'Lee 74' and 'Centennial' Soybean Cultivars

Soybean cultivar	Treatment	Root nitrogen		Shoot nitrogen		Total nitrogen	
		%	mg/plant	%	mg/plant	%	mg/plant
Lee 74	Control	1.84 a	11.5 c	2.46 bc	34.5 c	2.26 ab	46.0 c
Lee 74	BR	1.85 a	16.5 abc	2.94 ab	85.9 ab	2.68 ab	102.4 ab
Lee 74	SCN	1.78 a	14.3 bc	3.49 a	78.5 abc	3.04 a	92.8 abc
Lee 74	BR + SCN	2.03 a	21.0 a	3.17 ab	96.7 a	2.86 a	117.7 a
Centennial	Control	1.57 a	14.4 bc	1.95 c	38.7 bc	1.82 b	53.2 bc
Centennial	BR	2.12 a	17.9 abc	2.55 abc	64.6 abc	2.44 ab	82.5 abc
Centennial	SCN	1.67 a	17.7 abc	2.52 abc	65.2 abc	2.28 ab	82.8 abc
Centennial	BR + SCN	1.83 a	23.6 a	26.9 abc	87.8 a	2.44 ab	111.4 a
	LSD (*P*=0.05)	0.75	7.1	0.97	48.3	0.88	53.8
	CV (%)	23.59	24.0	20.63	40.4	20.59	36.1

* *Means within a column followed by the same letter are not significantly different at the 5% probability level. Data are means of 3 replications.*
From the thesis of David Mersky (University of Arkansas, Fayetteville, 1992: p. 40). Used with permission of the author.

BOX 15.2 Adapted Table

Influence of *B. japonicum* USDA 110 (BR) and *H. glycines* Race 3 (SCN) on Nitrogen in 'Lee 74' and 'Centennial' Soybean

Treatment	Total nitrogen (mg/plant)	
	Lee 74	Centennial
Control	46.0 c	53.2 bc
BR	102.4 ab	82.5 abc
SCN	92.8 abc	82.8 abc
BR + SCN	117.7 a	111.4 a

From the thesis of David Mersky (University of Arkansas, Fayetteville, 1992: p. 40). Used with permission of the author.

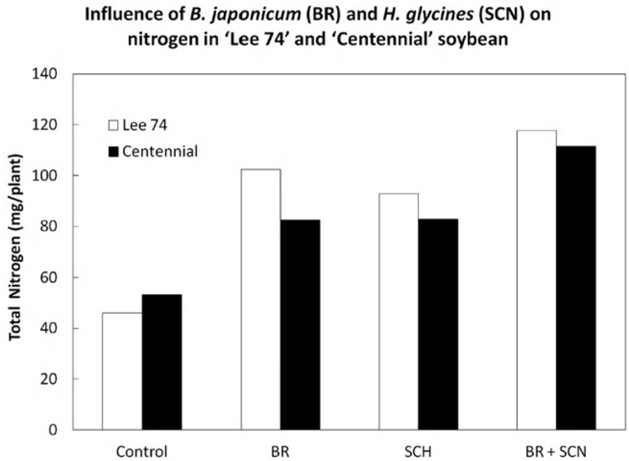

FIGURE 15.1 Graphic display appropriate for a slide.

3. Remember that projection will expand the spaces on the slide as well as enlarge the letters. Usually single space between lines of continuous text and 1.5 or 2.0 space only between ideas or to set apart a caption or heading.
4. Remember that the audience should understand the point on the slide immediately and do not overload it with information or visual distractions.
5. Ordinarily, do not number your tables or figures. You may want to rearrange your talk and put Table 3 before Table l. With slides in sequence with the talk, the numbers are superfluous.

6. In designing tables, space evenly between columns. Always align decimals.
7. Be sure lines and symbols in figures adhere to the same standards as text. Thin lines or symbols that are too much alike may be difficult to follow.
8. Be consistent with abbreviations and other symbols from slide to slide in the same presentation. This consistency should include color, symbols, or another communication device that is intended to carry the same message in one slide as in another.
9. Avoid the use of too many different colors. Any device for enhancement (italics, bold print, and underlining) that attracts attention to itself but serves no additional purpose is a distraction from the content.
10. Use animation sparingly but appropriately. Use clip art rarely or never; your own photographs or drawing will serve you better.
11. Ask a colleague to review your slides and offer an opinion. What appeals to you may not appeal to someone else. You may want a second or third opinion, but if a point is questionable, there is probably a better way to compose the slide.
12. Make your slide set long before you need it, and be ready to revise it.

15.2 SLIDE PRODUCTION

A number of techniques are available for making word slides. One method is not necessarily better than another; success depends, first and foremost, on your slide composition. No technique will make a good slide from poorly composed copy. Beyond the copy composition, the effectiveness of your slides depends on your judgment and your skill in using a chosen process. Computers have made slide making much easier. Some good software programs are available. Choose a program that can provide various font styles, colors, symbols, and other embellishments that will allow you to follow the principles of good slide output. Of course, if you have available an electronic projector or digital device for your presentation and software such as Microsoft PowerPoint to design your slides, you have advantages of being able to quickly compose slides and to revise them immediately.

No matter what method you use, keep in mind the standards for slide composition. Although the computer can produce multiple boxes, three-dimensional images, thousands of colors, shadows, animation, and intricate details, **a simple slide is still the best slide**. Animation or computer clip art seldom help your visual aid. A neat unobtrusive logo or a new point moved into the slide and a previous one faded to the background can help audience understanding, but do not get too carried away with the artwork; it can clutter up a perfectly good slide. You want your audience to focus on the scientific message on the slide, comprehend that idea in a few seconds, and keep their attention on what you are saying. Do not let that focus be distracted by something clever your computer program will do.

Slides and other visual aids can contribute to the success of an oral presentation. **But it is better no visual aid than a bad visual aid.** Computer technology has not eliminated poor judgment on the part of speakers. At almost every professional meeting I have attended, I have witnessed a speaker who projected a totally illegible slide on the screen and told his or her audience, "I'm sorry this slide is bad, but here you see …." Then the speaker would proceed to point to something I could **not** see. Do not apologize for a bad visual aid; do not use a bad visual aid. A blank is better, but you should be able to come up with a slide that supports what you are saying at that point.

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Chapter 16

The Oral Presentation

To speak much is one thing, to speak well another.

—Sophocles

You have done scientific research on a certain subject and have established a degree of expertise in that area. You are ready to make an oral presentation in an academic seminar, at a professional meeting, at a job interview, for your company, or to a local civic club. My first suggestion is that you read "Let There Be Stoning" by Jay Lehr (1985). A copy of that editorial appears in Appendix 14. Lehr suggests that boring speakers waste our time and that they should be punished. We should demand excellence in professional presentations the same as we do in published papers. After reading Lehr's vivid analysis of what it takes to make a good oral presentation and before you start designing slides, think about who makes up your audience and what you want to tell them. With the **audience** foremost in your mind, consider your purpose and subject; your own personality and ability; the time you have; and any other influence on the outcome of your presentation, such as the physical setting, other speeches, and the presence or absence of a moderator. Then prepare your presentation, and do not make the audience suffer.

You may want to write a draft of a speech, but do not memorize it or read it to your audience. Just let brief notes from the speech and especially your slides prompt you while you are talking. Many people can work better from an outline, but do not rely totally on the written word in any form. Make the speech in conversational tones with as much eye contact with the audience and as little reference to notes as possible. Most important, condition yourself, allow time, construct a slide set you are proud of, organize material carefully, and practice with a reviewer.

16.1 CONDITIONING YOURSELF

Before any oral presentation, you need to prepare yourself for the intensity that you should feel while you are speaking (Figure 16.1). If you are a good speaker, you will feel this intensity, so do not let it frighten you. You need to practice, yes, but you also need to be relaxed and enthusiastic about your speech. If you fail to get enough sleep or if you practice repeatedly up to the

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FIGURE 16.1 Prepare yourself for the intensity you will feel as you begin your speech.

last hour before the talk until the speech is almost memorized, you may sound as though you are bored with the entire presentation and just reciting it. It is far better to prepare the presentation several days ahead of time, have someone review it, revise it, practice, and then put it aside until just before you go on stage. Get a good night's sleep, dress appropriately for the event, approach the talk with confidence and enthusiasm, and as Lehr (1985) said, "Let there be an end to incredibly boring speakers!"

If you have questions about the organization of your report or if there are technical points that are not clear to you, spend some time before the presentation talking with a professor or other colleagues who can help you. Be sure you are familiar with your data and details in your own research as well as the background literature that has been published on your subject. You must understand your data and the analysis and scientific principles involved with those data. If you do not understand your subject, you cannot expect your audience to understand it after listening to you.

Many organizations publish abstracts to their scheduled presentations well before their meetings. A well-written abstract can be a great advantage to you because the audience is listening for what you have to say about the major points in that text. If an abstract is not available, you may want to bring a few copies with you to make available after your presentation or offer to e-mail the abstract or the presentation later. To distribute it before or during your presentation can be distracting and time-consuming. An abstract must be short or its purpose will be defeated. If the abstract is a handout for the meeting, a list of related references can accompany it, but the abstract itself should contain no literature citations.

You may have to introduce yourself. If so, make it brief, perhaps just your name and the subject of your presentation along with a comment on your

pleasure in being there. Better still, a host or moderator may give an introduction. Then the floor is yours for the designated time. If you are nervous before and during your presentation, do not be unduly disturbed. Most people feel some nervousness in the speaking situation; use that feeling of intensity to make you alert, eager, and animated. Confidence will soon take over if you are well prepared. Above all, do not let the nervous energy make you talk too fast to be understood.

Try to enunciate clearly. Make a special effort to speak slowly and loud enough so those in the back of the room can understand you. It is extremely rare to have a speaker speak too loudly or too slowly, but many presentations are ruined by those who speak too fast or cannot be heard. If a microphone is available, use it even if you think you do not need it. Face your audience as much as possible. Look at them; eye contact is important for holding their attention. Try to avoid such nervous mannerisms as hiding your hands in your pockets, fiddling with objects in your hands, or unnecessary waving of a pointer; these displays are extremely distracting to the audience.

The pointer, the remote control for slide advance, and a microphone are equipment you may need to deal with while you are speaking. Practice with various kinds of these tools. Pointers can be distracting. If the remote for slide advance does not include a laser pointer, you may be issued a light pointer or a stick pointer. Learn to be comfortable with either. If the audience is small, you may be able to simply gesture to your point on the slide with your hand and avoid any distraction with a pointer of any kind. With a large audience, the pointer can be helpful to direct and hold the audience's attention to a point on the screen, but turn it off or lay it aside when you are not using it. Otherwise, the light pointer can turn into a distracting series of flashes across the audience, and the stick can appear to be a baton and you an orchestra conductor. If the light pointer is on the remote control for the projector, be familiar with all the buttons and do not change the focus or turn off the slide rather than point to it. The equipment in a meeting room may not be identical to that with which you practice. To avoid appearing incompetent, become acquainted with it, if possible, before you are introduced.

The microphone is a valuable accessory, especially in a large room or for a voice that does not project well. Take advantage of a good microphone; it can help you provide quality in tone and enthusiasm. As with the pointer, you need to become comfortable with the microphone. You may have to adjust to the kind used, and more problems occur for women than for men. The microphone may be a clip-on that can be attached easily to a tie or suit lapel, but it can be unduly heavy on a thin blouse or dress and even worse if the garment has no lapel. The microphone may be stationary on the podium, or it may be on a cord that is put around your neck. These can be better for women, but anyone needs to be conscious of the range of the stationary one and not walk too far away from it. You may even have a microphone that uses a wireless sensor to a speaker system. These are simple devices that slip easily into the pocket of

a man's coat or pants but may not be suitable for some women's clothing. The best solution for women or men is simply to wear a jacket on the day of one's presentation.

16.2 TIMING

Recognize that timing is important, not just for beginning and ending a speech but also during preparation and delivery of any talk. Boil down your remarks so that you can present the significant points and auxiliary explanation within the allotted time and give adequate coverage to each point of emphasis. As McCown (1981) suggests with posters, a good idea is to start with your abstract and enlarge upon the points it contains with examples and details. Planning for a speech and designing visual aids should begin as early as possible before your presentation. In fact, as you do your research and data analysis, you should be planning for the delivery of results to an audience. Take photographs and design other visual aids throughout your study. Even with modern technology, you should plan to have your presentation in its final form at least a week before the actual delivery. In addition to conditioning yourself to make a fresh and enthusiastic presentation, this time allows for the possibility of correcting errors in slides or making other adjustments in the presentation after a review by your peers.

You will seldom have an opportunity to set your own time limit for a presentation. For some situations, such as a presentation for a job interview, you may be given a generous range of time. A prospective employer may test your judgment by suggesting that you take "20 to 30, no more than 40 minutes." Wisely plan that presentation at 25 minutes; your audience will probably want to ask questions, and the attention span for most people is less than 30 minutes. In other situations, you will be given a designated time within a program. That time may be very specific—"15 minutes: 12 for the speech and 3 for questions." Such a request gives you very little leeway, but you will note that others have the same limits, and it is rude and unprofessional to finish too soon or to run over into someone else's time. The program chair expects that you will fill your time slot and does not want to get off schedule by starting the next presentation too early or too late. A good moderator will insist that you finish in time and will simply stop you if you talk too long. Your conclusions are important; do not let them be deleted by talking too long.

Timing is also critical during the speech itself. Give your main point the most time. Do not spend much time on side issues. Usually the time allotted at a professional meeting will allow you to make only one or possibly two main points. The way you use the time for exhibiting that point depends on your organization. The pace with which you move through the presentation is critical to audience reception. Allow for a relatively slow pace and for pauses. Anholt (2006) suggests that slowing down is a remedy for 90% of most speakers' problems. Slow down and remind yourself to provide the audience with time to think by using pauses, full stops, and a relatively slow pace. A friend of mine, who is

an outstanding speaker, writes **slow down** as a reminder at the top of each note card. If you have a tendency to talk fast, you might do the same. The speaker who gives the audience a second or two to think just before and after he or she makes an important point usually maintains the audience's attention far better than a speaker who drones on without clear pauses in the delivery.

16.3 THE VISUAL AIDS

Even with the same subject, visual images selected should be somewhat different for any different audience. Your colleagues in science may understand a complex graph that would be lost on the audience at the job interview or the civic club. The latter audience might enjoy seeing a picture of equipment you have used, but the scientists may have seen such instruments so often that if you simply name the piece of equipment, an image is in their minds without the need for a photo. After you have thought about your audience and your purpose, only then are you ready to consider the content for slides.

Seldom should you put words on a screen and then say those exact words without further comment. In other words, do not read your slides to an audience. Exceptions to this idea can be your title, your objectives, and your conclusions. Again, the emphasis with visual and verbal duplication is not only acceptable but also can be highly effective. Be selective in what you duplicate. You can introduce your subject without reading the title verbatim, but it is usually best to comment on the essential words in it. It is good to read the objectives and conclusions and add commentary with each. For almost every other part of your speech, do not read your slides or bore your audience by putting the full text of your speech on the screen. Instead, select key words and other images, display them, and expand upon their meanings orally. Cover all the points on the slide in the order in which they occur. This technique allows you to keep brief text on the slides that the audience can comprehend at a glance and then move their eyes back to you to get the most from your voice and body language. Use a pointer discreetly to direct or hold their attention to a point on a slide, but put the pointer aside when you are not using it. Study the principles for creating and using any visual aids before making your slides (see Chapter 15 and Appendix 13).

16.4 COORDINATING THE VISUAL AIDS AND THE SPEECH

As you organize your talk, consider the audience and the time you can give to each portion of the content. Speech teachers may tell you that you should roughly divide your talk into 10% introduction, 80% main body of the speech, and 10% conclusion. That division makes a good standard to begin with, but often these percentages should be altered to provide more time at the beginning or the end for explanations that are crucial to a particular audience's understanding. Table 16.1 outlines a typical example of contents for both the text

TABLE 16.1 **Typical Content for a Presentation Reporting Scientific Results**

Speech content	Slide content
I. Title	
Title	Title and authors
II. Introduction	
Hypothesis	Full statement
Justification	Key words, pictures
Literature	Ideas and references
Objectives	Full statements
III. Methods	
Equipment and materials	Illustrations or lists
Sampling and technique	Lists or flow charts
Methods of analysis	Summary or key words
IV. Results and Discussion	
Objectives accomplished	Statement and pictures
Data	Tables, figures, key words, photographs
V. Conclusions	
Accomplishment of objectives	Full statements
Accuracy of hypothesis	Statement or photograph
Application of results	List or picture

and the slides for a research presentation. These are examples that usually work well. Your subject may require that you use other forms and content.

For any speech, with or without visuals, your introduction needs to let the audience know what your subject is and how you will approach it. Once you have identified your subject and provided a justification or hypothesis and the specific objectives for the substance of your talk, the best introduction is usually a general outline of what will follow: “Today, I’d like to discuss two issues …. The first is …, and the second ….” Or “We can follow the development of this theory through 3 stages: 1 …, 2 …, 3 ….” The audience can follow you more easily if they have that initial outline of information. Most important is that you make clear your objectives. From that point, take the speech through the development of your points, and draw a conclusion by reiterating the main points and suggesting an interpretation based on your development of ideas. With any speech, decide what you want the audience to know

and carefully set up your objectives and conclusions with adequate intervening material to support both. Then ask for a second opinion about how well you are communicating and revise the order if need be.

Paramount to making your slides aid you in your presentation is to have them well organized and carefully coordinated with your speech. **A title slide, an objective slide, and a conclusion slide** form the foundations around which you organize your talk and your other slides. Even these may be modified for different audiences, but they will exist in one form or another in any good slide presentation.

The **title slide** should focus on what you are going to talk about. It should be clear and aesthetically pleasing. Beyond your own appearance, it may be the first impression you make on your audience. In addition to the title itself, this slide should contain your name and the institution or agency you represent (if you do). It may also sometimes contain a photo of the main subject of your talk. Some people argue that on most occasions, a host or a moderator will have introduced the speaker by name along with the title of the presentation and, therefore, the slide need not repeat that information. I believe such information bears repeating. Here is another legitimate use of duplication in speech. Even though your title and your name have been announced, a visual aid can reinforce that information or provide it to those who did not hear or understand the moderator. Especially at the beginning of your talk, some people in the audience are not paying attention. Your title and identity are important; double the listeners' chances of having that information. In addition, a title slide serves as a backdrop for the introductory remark and the main point of emphasis in your speech.

The **objective slides** should briefly state the research objectives that you are going to discuss or else show the audience the purpose or outline of the speech you are presenting. Objectives should be limited in number; it is hardly feasible, even in a relatively long speech, to present more than three research objectives, and one or two are better. They should be worded as briefly as possible, but do not neglect clarity for brevity. You may wish to read each objective verbatim from the slide and then pause and discuss its meaning or why you have chosen that objective. Move slowly over the objectives; you may want to put each on a separate slide to slow you down or move each objective onto the screen individually. The objectives constitute the heart of your discourse; be sure to emphasize them and give them the time and importance they deserve.

The importance of **conclusion slides** also cannot be overrated. The listeners may forget most of what you have said, but if you will present dynamic conclusions, they will be able to carry your point away with them. Remember that the content in your conclusions should be coordinated with that of the objectives. Your objectives should state your goals, and the conclusions should indicate the extent to which you accomplished them. Unlike most other slides, conclusions can be in complete sentences, and as with the objectives, you need to move through them slowly and deliberately. Embellish each with brief reminders of what you have said in the body of the talk that led to the conclusion. Most

important, keep your voice alive and enthusiastic. If someone's attention has wandered, it is time to emphatically call that attention back to your point. Use pleasant but forceful words and voice; punctuate with appropriate facial expressions and hand or body movements.

Once you have designed your title, objective, and conclusion slides, you are ready to fill in between them. Your first task along with the title is to make clear your point of emphasis, your subject, your hypothesis, and the justification for doing your study or for presenting your ideas. Even before your title slide, you may wish to show a photograph or two that provide justification for your study or a visual image of a species or a condition you will be discussing. For example, if you have been studying the habits of the endangered American burying beetle, you may want to show a close-up of the beetle. Not many people have seen one in recent years. During the showing of no more than two or three such photographs, you can explain the value of the beetle in the environment, the fact that it is now endangered, and the need to understand its habitats and habits. Some of that justification can be done before the title or all of it after the title, but along with the objectives you will want to enlarge upon the justification as much as your introductory time will allow. Present your own hypothesis and reference to literature that relates directly to your study. For instance, you may need to compare or contrast your work concerning the American burying beetle with that on similar species. Objectives may conclude the introduction after you have justified your study, or they may come soon after the title prior to that justification. No one pattern for organization is better than another, except for a given subject and a given speaker. In other words, the **introduction** of your speech and the visual aids that accompany it will include a title and objectives with other supporting material that can be arranged in any of various patterns around these two essentials.

The remainder of your presentation will be much more lucid if this introduction is clear. Characteristically, in a presentation on typical research findings, you will move from the introduction to the **methods**. Think of what unspoken questions may be in the minds in your audience. They may be pertinent, or they could get you off track. Stick closely to your purpose. Your responsibility is to answer the right questions and guide the audience to your point. If your topic is the American burying beetle, your audience may want to know how you trap the beetle, how you get a license even to handle the endangered species, what data you collected, under what circumstances you observed the beetle, what analysis you used—the list of questions can become endless. You must decide which questions are most relevant to the focus of your speech and how to answer them in the time you have to devote to methods. Let your visual aids then support your answers. You may have slides in the form of diagrams of the traps you use, photographs of the area where you trap beetles, or photographs of the traps. You may have lists of materials, a statistical design, or categories of data such as eating habits or flight habits of the beetles. For an audience that is mostly interested in your results, do not spend too much

time on methods unless your objective was to study methods. Your basic design for the experiment, the kinds of data collected, and the statistical analyses used usually provide enough information to tell an audience that you have pursued your objectives in a scientific manner; then go on to the results.

Again, your audience is crucial to the way you handle the **results and discussion** section. Present representative, selected data to illustrate what you have accomplished in pursuing your objectives. Discuss any special meanings and implications that can be drawn from the study. Fitting your study in with those of others researchers further increases your credibility. Make reference to specific literature and use the names of other researchers. Such specific references will illustrate your depth of understanding the literature far more than a general allusion to "other researchers."

For those at a professional meeting who understand your technical and scientific terminology and are accustomed to seeing visual aids such as line graphs and bar charts as well as tables of information, you can rely heavily on these and other graphic forms to present results. For another audience, you may need more word slides or photographs. Certainly, for any audience a mix of word slides with field and laboratory photographs and graphic depiction of data is more informative and pleasant than all words or all photographs. Notice the mix in Appendix 13. Precision and clarity in communication can be increased by using a variety of different techniques for presenting an important point. In your presentation on American burying beetles, you might show results by providing numbers in a table, then a bar chart of information, and then pictures of the beetle to illustrate your observations and discussion.

Hold to your point of emphasis throughout your presentation. As with the methods, the results and discussion should flow from the objectives to establish whatever resolution your data provide for your hypothesis. Allude to your objectives, and then show the results and discuss their significance relative to those objectives. Once you have clearly enumerated results and shown the data in tables and figures and discussed them in relation to your main point of emphasis, you are ready for the **conclusions**. Be sure the conclusions clearly reflect the goals of your objectives and the main points in your results. Present them with emphasis.

Throughout the presentation, carefully coordinate the slide on the screen with the words you are speaking. Practice enough to be sure that the order of the slides as well as the order of information on each slide is the order of the talk and that you are comfortable with it. Critical to a smooth flow of the speech from beginning to end are the transitions that punctuate the presentation.

16.5 TRANSITIONS IN AN ORAL PRESENTATION

Often, the difference between an adequate presentation and an excellent one results from the pace of the speaker and the transitions he or she uses to move the audience along. Transitions slow you down and give the audience time to

think. Transitions get you into and out of the speech and move your content from one section to the next, from one point to another, and even from one slide to the next. The typical oral presentation based on a research project contains several strategic junctures at which you must carry the audience from one point to the next with clear transitions. Internal transitional devices such as those used in written work (see Chapter 3) can be used, but the situation in speaking is different, and the speaker must guide the audience.

The first transition many people overlook in oral presentations is the juncture that occurs as you begin the talk. If you have no one to introduce you, you will have to attract the audience's attention to you and your speech. Some in the audience are talking among themselves about subjects entirely unrelated to your speech, some are thinking about their schedules or their own speeches, and some are simply concerned with the weather or their comfort. Transitions here include such things as closing a door, stepping to the front of the audience, stepping forward toward the audience, or dimming the lights. You may have to say something like, "May I have your attention, please," but most professionals interpret all of these gestures as indications that you are about to begin. You may have to pause as those conversing finish a sentence or a late comer finds a seat. The important point is to have as much of the audience's attention as possible directed toward you and what you are saying.

Of all the transitional devices in the world, the *pause* is often the most effective in speaking. After you have made a remark, closed a door, and stepped forward toward the front row of your audience, a pause will do wonders to bring the audience to you. Even those in their own private worlds of thought will look up at a silence to ask themselves, "What's going on?" or "What's the speaker waiting for?" The key is to pause long enough to attract the attention but not long enough to lose it again.

A part of the responsibility for moving the attention of the audience to the speaker may belong to a host or moderator. This host may be the one to shut the door, to adjust the lights, to call for attention, and to make the strategic pause. Whether you or the moderator assumes these duties, the transition is not complete until you begin your speech. Once you have placed yourself in front of the audience and are ready to begin your speech, give the audience a moment to adjust to the way you look and sound. A casual remark, a smile, eye contact across the audience, and an introduction to your voice are in order. Thank the one who introduced you, and then **let your first sentence lead the audience toward your point, but do not let it be critical to their understanding your main point**. Their minds have a lot of baggage to check before they can join you. They have to put aside whatever else they were thinking and get used to you and the sound of you. Making this initial transition will probably take no more than 10 seconds, but it is crucial to a good beginning.

Equally important is the manner in which you leave the audience. Without a transition, an awkward moment occurs as the last word in your prepared speech is spoken and you are ready for questions or ready to leave the audience.

A moderator can be valuable at this juncture also. If the host will ask for questions and readjust the lights, you have the moment to let your mind relax, turn off your last slide, or prepare to answer questions. If you are alone, you must assume the responsibilities of both you and the moderator. At this final juncture, you must recognize how much time you have left, maintain a professional stance, and let the audience know what comes next. Do not loosen your tie or roll up your sleeves or stuff your hands in your pockets. If a question period is to follow, do not remove a microphone that has been attached to your lapel or around your neck. Be sure the last slide is turned off and the lights are turned on for the audience. Some people put a final slide on the screen that has the word "Questions" or simply the symbol "?" This slide serves no purpose. The focus now should be on you and your audience. Whether you or the moderator asks for questions, a good transitional gesture is to move a step or two toward the audience. This symbolic language suggests an invitation for the audience to join you; you are joining them. After you have answered the last question, the moderator may assume the transitional duties of making a closing remark, thanking you and thanking the audience for coming, and providing any additional instructions (e.g., there will be another speech or the management has asked that we exit to the right). Moderators are handy things to have. Without one, you need to finish the questions before your last minute is up and then summarize questions and the talk briefly—probably in one sentence—provide any instructions the audience needs, and thank them for listening to you. Above all, be sure to finish in the time allotted to you.

Perhaps you had not thought of the periods of opening and closing the speech as transitions. Treat these entrances and exits with respect. They may be the most important transitions you make. More likely, you think of moving from one section of your speech to another as needing transition. How do you leave the introduction and move into the methods, or how do you leave the discussion and move to the conclusions? These are certainly critical points at which you must carry the audience from thinking of one thing to thinking of another. Give the audience a smooth ride and they will not even notice the transition. For an oral presentation, some speakers will use headnotes on the first slide in a section to indicate "Introduction," "Methods," "Results," and "Conclusions." Do not repeat these words on every slide in the section, but these signposts provide obvious directions for your listeners and are sometimes appropriate and inoffensive. A photograph and transitional words often work as well or better. With or without the headnotes, your spoken words need to carry the audience to your next section. To get into methods from the introduction, you may remark, "To carry out this study, we set up two experiments. The first …." Or you may say, "To accomplish my objectives, I first acquired …." Such remarks are smoother than a blunt announcement of "Materials and Methods" and are more effective. Similarly, as you move into the results and discussion, you may have some sort of transitional slide, but you should also let your words carry the transition. Try something like "The data collected showed that our hypothesis was accurate"

and then move to a results slide that supports that contention. Or you may need to say, "Our results are inconclusive, but they do show that …."

Moving to the conclusions is critical. You must have the full attention of the audience in order to leave them with your main points. Sum up the essence of the results you have presented and move dynamically to the conclusions. "All of these results point to two conclusions" or "Although the data are limited, we can conclude that …" are simple and often effective entrances to the conclusions, but you may be able to be more creative than these remarks are.

Let's go back to the American burying beetle example. Your hypothesis may have been that the lights of the homes and cities throughout the country are attracting these beetles away from their natural habitats in dead carcasses and from their pattern of setting up homes in these habitats to produce and feed their offspring. Your conclusions need to lead us back to that hypothesis and your objectives. You could move from your results to the conclusions by showing a photograph of the beetle near a light or moving toward one. With this image you can declare, "Our results indicate that American burying beetles will not keep their minds on home and family when they see the lights up town. We conclude that …." You are ready at that point to exhibit your first conclusion slide, which will most likely reflect the outcome of your first objective. Your remark has given the audience time to digest their last thoughts about the data you have just presented and to move with you to the conclusions. Remember the value of the pause. A deliberate pause with a transitional statement can effectively attract the audience's attention. Let the slide on the screen fit the occasion and serve to support the pause and the remark.

In addition to transitions into and out of the speech and at major junctures, you need clear transitions all along the way. Transitional word slides or photographs can help. Whether a picture or words are on the screen, the important point is that the transitional slide is appropriate. Smooth movement from one idea to another may not allow time for an extra slide. As you linger momentarily over one slide, you draw a conclusion to that point and then move with a short transitional word or phrase to the slide displaying your next idea. For example, as you leave one data slide, you could be saying, "Contrary to what we found with these data …, [advance to next slide] the analysis of … showed that …." Such transition should be woven throughout the presentation.

Be careful not to keep repeating weak transitional words or phrases that become worn thin with overuse. Some to use with great caution include "Also, we see …," "And here you can see …," "Again …," and "Looking at the …, we see that …." Also avoid nontransitional utterances such as "Uhh," "And uh," or "OK." As Booth (1993) suggests, "Anderm' [is] the most irritating nonword ever misfangled." Make your transitions provide the audience with both meaning and think time. Instead of saying "Again," give the audience a little time to move from one point to another with a transition such as "Those data show us

the anatomical differences, but other data [advance slide] illustrate that physiological differences are just as important." Yes, it takes longer to make that statement than to say "again," but the audience has time to think about anatomy and be ready for the next point on physiology. **Taking time to think is essential to any good communication.**

16.6 THE PEER REVIEW

When you believe you have your content organized, laced together with transitions, and proportioned relative to time, go through your speech with your colleagues. Always accept healthy criticism. Their vantage point is closer to that of the audience than is yours. If slides or speech content and organization are not clear to these reviewers, revise your materials until they are clear. As you make increasingly more talks, you will become more sensitive to what works for you and the audience. When you have gained experience, do not be afraid to go it on your own, but always welcome reviews. In addition, during the speech be sensitive to the audience reception and be willing to deviate from your prepared material if you recognize that their attention or understanding is straying or entirely lost.

These general comments on timing, organization, and review will not make a good speaker of you. As with learning to swim, the only way to develop the skill is to do it. If you follow the basic conventions for good speech making and repeatedly practice the proper moves, you can become an accomplished speaker. Anholt (2006), Booth (1993), and Lehr (1985) have good suggestions for making scientific presentations. The following checklist may alert you to points to observe in your own scientific presentations and those of others.

16.7 CHECKLIST FOR PROFESSIONAL ORAL PRESENTATION

I. The Speech

A. Introduction

1. Are your hypothesis and objectives clear for the audience?
2. Do you provide the audience with clear rationale and justification for your study?
3. Does your introduction follow a logical pattern, and is it related to other literature and to scientific principles?

B. Materials and Methods

1. Do your methods have the support of the literature and scientific principles?
2. Do you show a logical, step-by-step process for executing the experiment and collecting the data to carry out your objectives?
3. Do you make clear your use of appropriate experimental design and statistical analyses?

- **C. Results and Discussion**
  1. Do you summarize results—that is, emphasize main points—as you **begin** and **end** this section?
  2. Do you relate the results clearly to your objectives?
  3. Do you carefully choose a limited number of data points to support your contentions and present them in simple illustrations, graphs, tables, and lists?
  4. Do you discuss your points in terms of:
     - a. their relation to other research?
     - b. their practical or scientific applications?
- **D. Conclusions**
  1. Do the conclusions reiterate main points for the audience to remember?
  2. Do you show a list and clearly relate it to your objectives?
  3. Do you give examples of application and use for your findings?

II. Visual Aids (see also Appendix 13)

- **A. Number**—Are there too many or too few slides for the time you have?
- **B. Content**
  1. Are the slides clearly coordinated with your speech?
  2. Is the purpose of each slide readily apparent?
  3. Do you have a balance of data, lists, and information slides with illustrations interspersed throughout?
  4. Have you included all expected slides: title, list of objectives, conclusions?
- **C. Quality**—Are your slides …
  1. Neat and spaced to fill the screen?
  2. Simple and free from excessive data?
  3. Easy to comprehend—for example, proper size print, good content, good design, and clearly labeled axes?
  4. Free from garish color or any other embellishment that could distract from your message?

III. Speaker

- **A. Are you prepared?**
  1. Are you familiar with your speech and the slides?
  2. Will you and your audience be comfortable with your appearance?
- **B. To what extent do the following support or distract:**
  1. Mannerisms and gestures?
  2. Audience contact (eye contact, facial expressions)?
  3. Voice, speech patterns, and ease in speaking?
  4. Your attire, posture, and poise?
- **C. During the speech, keep the following in mind:**
  1. Avoid reading from the slides or from notes.
  2. Be sure your eye contact covers all the audience.
  3. Put the pointer down or turn it off when you are not using it.

4. Let your hands talk with you; do not put them in your pockets.
5. Never apologize or make excuses for a bad slide. A bad slide is worse than no slide.
6. Keep your voice enthusiastic and loud and slow enough.
7. Allow enough time to speak slowly and insert appropriate pauses.
8. Be sure to use enough but not too much time.

As with any other skill, it takes a great deal of practice to become a really good presenter. It also takes some instruction or coaching and some self-scrutiny of your strong and weak points. To video your presentation and critique yourself is helpful. Having someone else discuss that presentation with you can further enhance the learning. It also helps to critique presentations by others and make comparisons with your own. Be willing to spend some time developing these skills. They may be among the most important qualifications you exhibit for success in your career. Study the presentation in Appendix 13. It is a report on a simple preliminary research project and shows good organization and content, and spacing of slides is arranged in a mix of words, photographs, and other visual images.

Recognize all the elements that come together in a successful oral presentation, practice them, and be proud of your performance. A good slide presentation coordinates communication among the speaker, the speech, the visual aids, and the listeners. It has a specific purpose and is directed toward a specific audience. Be conscious of all the influences on the speaker, the speech, the listeners, and the visual aids, and control these as much as possible. Check everything involved, including the physical setting, the pointer, and the microphone. Prepare with good slides, clear organization with appropriate transitions, and a peer review of the presentation. During the talk, be alert to the reception by the audience and the role of the moderator. Maintain a professional attitude before and after the talk as well as throughout the presentation, which includes the question–answer session. Confidence and a dash of humility will lead you to success.

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Chapter 17

Poster Presentations

Only the composition as a whole determines the good or bad of a piece of graphic work.

—Eduard Imhof

Posters have become a major format for communicating at scientific meetings. The techniques vary with different societies, but typically the poster will be on display for a day or more, and the authors will be present during a part of that time to discuss the subject with viewers. Depending on the meeting, the number of posters displayed together may range from a dozen to several hundred. At any one time, the audience for each poster is a relatively small group of interested people. Presenting a poster is a good opportunity to build your reputation as a confident, knowledgeable, articulate scientist if you exhibit an attractive, informative display and maintain a professional role as the author and presenter.

The evolution of poster presentations at professional meetings has brought the technique from awkward beginnings of pinning a manuscript or main points of a manuscript onto a display board to mounting sections into frames on the board. Finally, with computers and advances in printing technology, poster boards typically display a single large sheet of information arranged in the order of a scientific paper. Posters were introduced into scientific meetings in the United States in the 1970s (Maugh, 1974). They rapidly became a way to present large numbers of research reports and have been widely accepted as a viable complement and alternative to slide presentations and symposia or workshops.

Posters offer advantages both for meeting arrangements and for communication efficiency. More posters can be scheduled in less space than can oral presentations, and those attending meetings have access to more papers in the same amount of time with greater flexibility for their own schedules (Figure 17.1). Some convention centers can provide large areas and display boards more easily than they can provide numerous meeting rooms and visual projection equipment. The advantages to individual communication are as appealing as the tactical convenience in arranging for a convention. In addition to giving the audience flexibility with regard to when to view the poster, the method provides a two-way interaction that is less feasible with the slide presentation. The poster presentation may turn into a profitable question-and-answer session, with both the presenter and the audience deriving mutual

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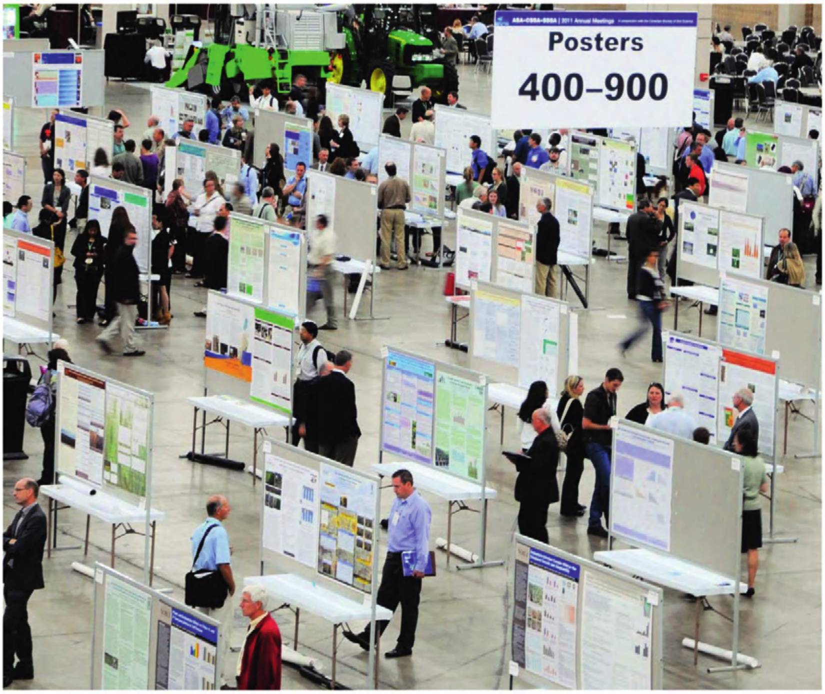

FIGURE 17.1 Many posters on display at the same time allow for flexibility in viewer schedules.

benefit from the ideas exchanged. Compared with the slide presentation, the poster technique provides more convenience for following up on ideas. Names and addresses or phone numbers can be easily exchanged, and the viewer will more likely contact the person he or she has spoken with face to face.

Generally, the author or presenter must be present with the poster at least part of the time, but some societies are now able to accommodate the "virtual poster." Virtual posters are sent electronically to screen monitors available for viewing at the meeting. These can accommodate presenters who cannot attend the meeting, especially those in foreign countries who cannot arrange to travel. An electronic exchange can provide an interactive format between authors and viewers. Virtual posters are still in the pioneering stage of development and present many of the same advantages and disadvantages of other distance communications that lack face-to-face exchange.

The poster has evolved rapidly compared with the few hundred years required for the evolution of the published or spoken scientific report. However, we still struggle with standards and guidelines relative to form, content, and construction of posters. The poster involves differences in audience participation and in communication techniques. Relative to cartography, Imhof (2007) declared that "only the composition as a whole determines the good or bad of

a piece of graphic work." This idea is also true for posters. A successful poster must communicate through every visual and written detail as well as the spoken exchange when the presenter is present.

Some of the same communication devices used for slide presentations and written reports can be adapted to the poster format. A quality poster balances the visual, oral, and written elements more fully than either the slide presentation or the scientific manuscript. In all three forms, along with a presenter, the basic communication devices include the text; type size and style; color and texture; shape and arrangement; and illustrations of data in tables, figures, or photographs. In using these tools, keep in mind the concept of unity or "the composition as a whole," and remind yourself of the basic purpose of any scientific communication: to convey clearly a scientific message to an interested audience.

17.1 AUDIENCE

As with any other communication, with posters you need to have as much concern for the audience as you do for your subject and your presentation of it. The viewers are standing 1 or 2 m away as they read the poster. The material must be attractive, interesting, and clearly readable to keep their attention. Meetings offer many attractions that compete with your poster for the viewers' attention. Also, readers are standing, and it is tiring to read from the standing position for very long. Most of them will look at the main points of your poster and then move on. O'Connor (1991) said that a typical poster reader will stop, read, and move on—all in 90 seconds or less. However, those who stay beyond 90 seconds are likely there because they are interested in your poster and your subject. Design and present your poster in such a way that you keep their interest and that the experience is worth their time and yours.

Woolsey (1989) suggests that your poster audience can be categorized into three groups: (1) colleagues who follow your work closely, (2) those who work in the same area but not on the same specialty, and (3) those whose work has little or no relationship to yours. He suggests that the middle group is your target audience. Those in the first group may stop at your poster to see how you have presented information they already are familiar with and to see what new data or details you have discovered. Viewers from the third group are not the audience you need to attract anyway; they simply pause to catch your main point or peruse your techniques in poster construction and, not having a direct interest in your subject, they move on. Members of the second group are interested in your subject and are not familiar with your data. If your poster is clear and attractive, they will probably stop longer than O'Connor's (1991) 90 seconds. To accommodate all three groups, you poster should be

- brief and clearly organized;
- simple with an obvious central point;

- easy to read from 1 or 2 m away; and
- attractive and aesthetically pleasing.

A closer look at the details that go into a poster can help you satisfy these criteria.

17.2 CONTENT

Scientists have been presenting posters at scientific meetings in the United States for more than 35 years. It is time we provide clear guidelines to make the technique effective and rid ourselves of poster boards overloaded with text, clutter, and remotely related illustrations that bury good objectives and results of a study. The Council of Biology Editors published a pamphlet by Peterson and Eastwood in 1999 on guidelines for posters. The same year, Gosling (1999) published an entire book on the subject. Before and after that time, other authors have offered instructions on poster displays, and the Internet contains a great deal of information that can be helpful to those constructing and presenting posters. However, the people who attend poster sessions still come away with the same criticisms that were mentioned in a survey of poster viewers that Davis et al. (1992) conducted in 1990. Viewers still say that the posters are too cluttered, arrangement of parts is poor, colors are often distracting, the text is too small, and there is too much of it. So let's get serious about McCown's (1981) suggestion that the poster should be an "illustrated abstract." If we can write a 200- to 250-word abstract for publication that can stand alone, surely we can extend those words with graphs, photographs, and tables and present an uncluttered poster.

To make the poster an extended abstract, first we must dispense with the idea that a poster is a scientific paper with all its introduction, literature, detailed methods, results, detailed data, and discussion. Then we may be able to get a simplified, readable, attractive, and effective presentation onto a relatively small display board. Look at each section of your abstract and see how you can extend it but keep it simple and complete for your poster.

The **Introduction** for an abstract is simply a statement of justification and your research question or hypothesis presented in one sentence or two at most. The poster introduction should provide a rationale or justification for why the work has been done and state a hypothesis or pose a question. If necessary, it can include a mention of a previous work you or other researchers have done that serves as background to your objective, but if this background is not essential for understanding of your hypothesis and objective, leave it out. This poster introduction should take no more than four or five concise sentences. Separate your objective from this introduction and let it stand prominently alone. The objective may be the first thing the audience looks for after reading the title. Present it clearly and simply. If you have two objectives, list them. More than two indicate that you have too much material for a poster. As on a slide, the objectives should not be full sentences. Introduction and objectives should not

need to occupy more than part of the first column of your poster, and there should still be room for methods.

Look at the **Methods** in your abstract. Unlike the scientific paper, which should present details of the methods, methods in the abstract and the poster need to do no more than provide credibility to your results unless your entire study was to develop or test a new method or details of a method are essential for understanding a result. Usually, the methods in a poster should simply state what procedures were used to conduct the study, to collect data, and to analyze them. You may be able to present these things in a half dozen sentences in the poster, but if possible use a flow chart or list of steps in the process. Then make a short statement on the kind of statistical analysis you used and move on to the results. Keep in mind that you will be present at a scheduled time to provide additional information for anyone particularly interest in the procedures you used. Certainly, if you can summarize methods into two sentences in your abstract, you probably can get them onto the first column of a poster along with the introduction and objectives.

In the abstract, **Results** and **Conclusions** will probably occupy half or more of the document. On the poster, they likely deserve more than a full column with a bit of discussion mixed in. Keep the audience in mind at all times. The objective and results are what most viewers want to see on the poster. What did you find out about the objective? Make a simple statement of the main outcome of your research. One sentence may be sufficient; two should certainly be enough. Then viewer interest typically goes to the data. Present them with as little text as possible, providing the audience with data in graphic forms, photographs, and tables. The text simply needs to point out what the table or graphic form displays and also the main point. Sometimes a photograph or photographs are good to show the effects of a treatment. Graphs are usually better than tables. It is easier to compare lines or bars quickly in a well-constructed graph than to compare several numbers in a table. Keep all tables and figures simple by using representative data. Do not distort your findings, but often you can omit columns or lines where no significant difference can be seen unless your point is to show that your comparisons are not different. See the example in Appendix 10, Figures A10.1a and A10.1b.

Your abstract should have no discussion or, at most, a sentence. **Discussion** in the poster should also be absent or brief and is often mixed with text of results. For the most part, reserve the discussion for the oral conversation with viewers. Those really interested in your study will try to be at your poster presentation when you are scheduled to be there. A concisely worded list of conclusions can eliminate the need for any discussion on the display, and a greater focus on the conclusions can initiate the oral communication. Relative to presentation of some of your data, you may need to mention a comparison or contrast to another author or authors who have worked on closely related studies, but do not overload your poster with literature and discussion. Give the audience a clear, uncluttered view of your data, and be prepared to talk about its meanings.

In addition to results and the conclusions, on a three-column display, the final column will usually contain any **References** and **Acknowledgments**. Without a lengthy introduction and wordy discussion, you should have few references, but be sure to list any you have mentioned. In your oral discussion with viewers, be able to discuss how your work compares to that of others. Also in the last column recognize those who have contributed measurably to the study or to the poster display in a short acknowledgment section. There may be space in this last column for another photograph.

Some viewers may peruse the display when you are not present. The poster should reflect your credibility as an author by providing substantial justification for your objectives and by giving meaning to your results and conclusions, but extensive introduction and discussion texts are out of place. Visual communication with pictures, graphs, and other illustrations can be valuable. You should be present at the scheduled time to answer questions and discuss issues, but be sure the text of the poster will stand on its own for those unable to talk to you in person.

As you plan the content for your poster, the following ideas can aid in the audience's understanding:

- Think of the audience.
- Let nothing distract from your scientific message.
- Use relatively short lines and expanses of text and short paragraphs. More than 10–15 continuous lines will tax the audience's patience. Fewer are better.
- Present lists when possible, especially in such sections as the objectives, methods, or conclusions.
- Use visual imagery such as flow charts, drawings, graphs, and photographs.
- Select type style and size, colors, and spacing that make reading the text easy and pleasant.
- Provide appropriate handouts such as business cards or your e-mail address and a summary or abstract with your name and contact information included.

With these points in mind, carefully consider the content and organization of your poster. You are not writing a paper for publication. A full paper can be more complex because it can be read from a comfortable sitting position and can be studied and reviewed over a longer time. The concise, precise format of "an illustrated abstract of a publication" (McCown, 1981) should form the contents of the poster. To avoid long stretches of unbroken text, break in between ideas or sections with a new heading or a picture, table, figure, or other illustration. Long-running paragraphs are formidable, and few in your audience will read them through. Concise lists should substitute for running texts wherever possible. The presenter can carry some of the burden of

expanding any discussion orally, and handouts of additional materials can be made available.

17.3 MAKING IT FIT

Briscoe (1996) is correct when she maintains that "It takes intelligence, even brilliance, to condense and focus information into a clear, simple presentation that will be read and remembered. Ignorance and arrogance are shown in the crowded, complicated, hard-to-read poster." The poster format demands concise presentation of information and clear coordination of words and visuals. The content should be a full but brief report—not a full paper but a synopsis. In contrast to the written paper, the poster may omit the abstract, provide little discussion, and use more photographs and color. Because the poster itself is an "illustrated abstract" (McCown, 1981), and especially if the original abstract is printed in proceedings of the meeting, it is not needed on the poster unless the sponsoring society requires that it be posted.

The space allowed on a display board presents the challenge for communicating with posters with a clear, intelligible scientific message through written, spoken, and visual media. Poster display boards differ in size at different meetings. Some are as large as 4 × 8 ft (~1.3 × 2.6 m) or 4 × 6 ft (~1.3 × 2.0 m) and some as small as 3 × 3 ft (~1 × 1 m). They are usually mounted on a stand or a table and are oriented with the longer dimension horizontal. Before you begin to construct the poster, you must know the space and orientation you will have for your display. Decide how much material you can display effectively in the space allowed. Keep your audience and your scientific message in mind at all times.

With dozens of other posters also on display, yours will command a limited amount of viewers' time. The most common communication mistake that I have observed in posters occurs in the attempt to present too much material in the time and space allotted. This problem manifests itself in both too much text and too much data. Be willing to make one or two clear points and leave your other information for future presentations or papers.

In making the information fit the board, the second problem that distracts from the scientific message is poor construction, chiefly in overloading the poster board but also in arrangement and use of shapes, colors, and text. Keep the display simple and attractive. With colors, shapes, and illustrations or with words, no device should be used that is merely decorative and attracts attention to itself and away from the science. Of course, you want your poster to be aesthetically pleasing, but foremost you want the scientific message to be clear. These two objectives can complement each other. As Imhof (2007) says, "Clarity and beauty are closely related concepts." Standards of communication for any single visual such as a chart, a slide, or a photograph are also the standards for the entire poster composition. The completed poster must be able to stand on its own with

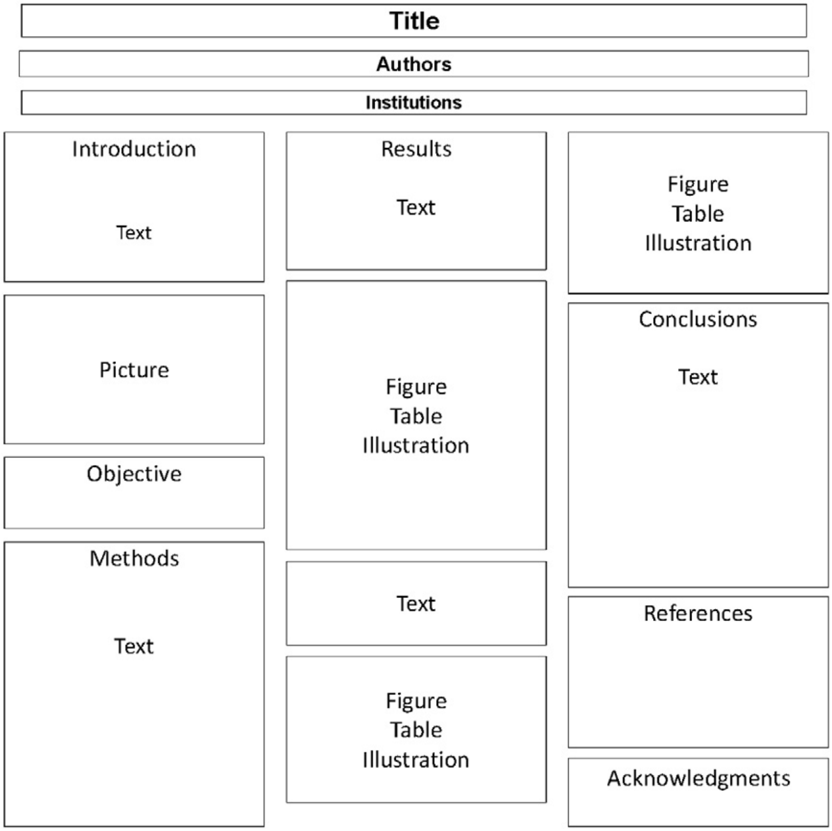

FIGURE 17.2 Possible format for a three-column poster.

all communication devices in place. The materials should be appropriate for the poster format, and the amount of content and the number of illustrations should not overload the message. The display should command credibility; communicate only a limited number of points; and be accurate, clear, legible, and concise.

In the layouts presented in Figures 17.2 and 17.3, notice first the overall impression. The smaller one represents a 4 × 4-ft (1.3 × 1.3-m) and the larger a 4 × 6-ft board. Their arrangement depends partly on the size of the display board, and obviously you can get more in the larger display. However, both follow the same basic principles of organization, legibility, and simplicity. Do not try to include more subject matter or objectives on a larger board; just add support for the limited points you make, chiefly with additional illustration rather than more text. These standards can serve as guidelines to help you design your own poster, but certainly not every poster can be arranged as these are. You may need more room for Methods and need to use less for

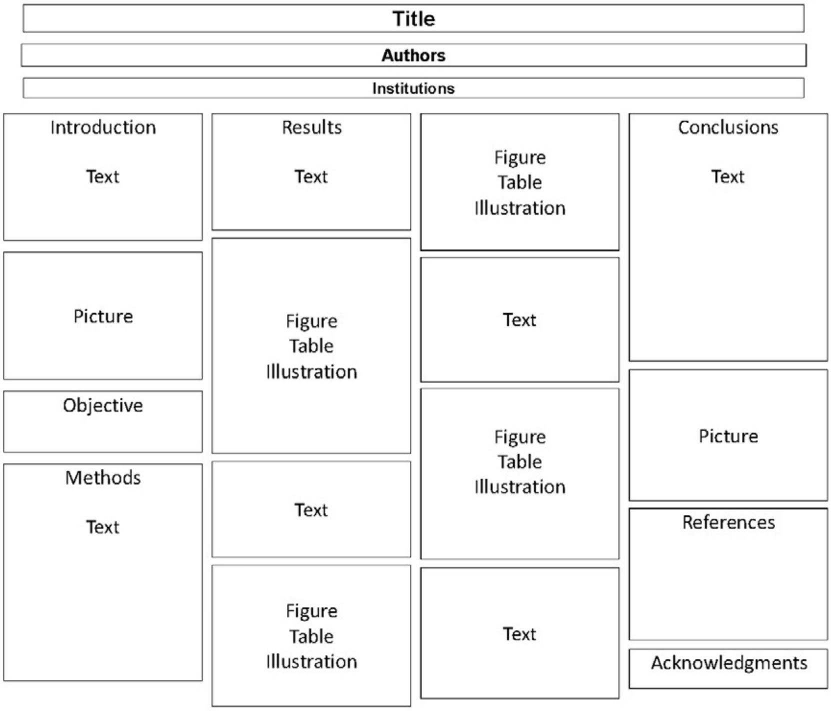

FIGURE 17.3 Possible format for a four-column poster.

Introduction or even Results. You may need fewer data displays and more text, but never overload the poster with text. The lengths of columns may create uneven top or bottom edges of the poster. That is not a bad thing. Figures 17.2 and 17.3 should merely serve as bases for constructing your own poster without overloading it.

The poster in Figure 17.4 demonstrates good characteristics, but like every other poster, it could be improved. It is a real poster presentation made at the 2011 meeting of the Soil Science Society of America in San Antonio, Texas. The space allowed was 43 × 43 inches. It basically follows the layout shown in Figure 17.2 and is arranged neatly in the order of an abstract with the addition of photographic and data illustrations as well as references that could not be inserted in the published abstract. It contains a great deal of text, but the spacing and type size make it easy to read. The font for the entire poster is Arial, and the size for the text is 26-point, for the title 65-point, and for the main headings 36-point. It is easy to read from a distance of 2 m. The lack of color is not a critical point, and a bit of emphasis is given to the headings with the yellow line. The black bars in the figures certainly convey the message but might be more attractive if they were colored, perhaps a dark green

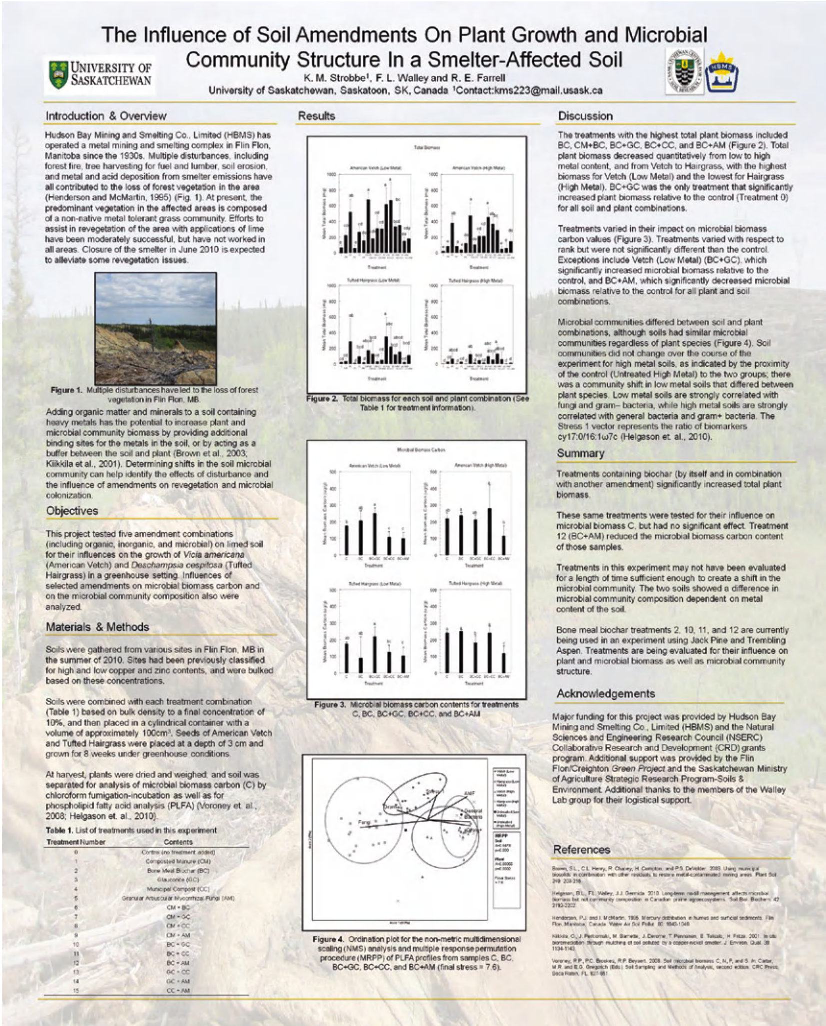

FIGURE 17.4 A poster presented at the Soil Science Society of America meeting in 2011. Reproduced by permission of K. M. Strobbe, F. L. Walley, and R. E. Farrell.

to represent the biomass from grass. The subdued image behind the poster text is not distracting, but with description in the introduction and the photograph, it is more likely to divert attention from rather than add to any clarity to the message.

Basic organization is standard. The introduction is comparatively long relative to its usual space in a published abstract and could have been shortened if more space were needed to separate and list objectives or to give more explanation to methods or enlarge the photograph. It is good to have objectives set

apart. They might stand out more prominently by listing them in incomplete sentences as in the following:

Objectives

1. To determine influence of organic, inorganic, and microbial amendments on growth of two grass species
2. To determine influence of select amendments on microbial carbon biomass and microbial community composition

Information on names of species and the greenhouse location would be saved for the methods.

Methods are relegated to an appropriate amount of space. If more were needed, the introduction could be cut. Results in the form of figures take the entire middle column with no text. The figures might be more immediately understood if a general statement of the overall outcomes of objectives could precede them or be introduced before each set of figures, but it is good to let the figures primarily tell the results and limit the text to calling attention to the main point in each data display. Discussion includes statements of results, and perhaps a heading of "Results and Discussion" over both columns would allow an initial statement of results to be made above the first figures, with a sentence preceding the second set of figures and stating a main point in that set. Then the final figure would move to column 3. The rest of the results and discussion could be in column 3 along with the summary, acknowledgments, and references. If most literature citations were cut from the introduction and text for the discussion were reserved for the presenter, the references in column 3 could be shorter and there could be room for another photograph to make the poster more attractive. Any additional references you might want to provide viewers could be available in a handout along with an abstract and contact information about authors.

Consideration of all these options for this poster and of the layouts shown in Figures 17.2 and 17.3 may help with your decisions as you prepare a poster display. Because every report is unique, you will have to be creative in arranging the parts. Stick to simplicity. As you critique any poster including your own, remember the main concern for posters as a means of scientific communication is that the media and presenter must provide a clear message. Secondarily but importantly, the poster should be attractive.

17.4 TEXT SIZE AND STYLE

Readability is of primary importance. Just as the message on a slide must be legible from the farthest seat in the room, so must the message on the poster

TABLE 17.1 Recommended Type Sizes for Posters[a]

Sample*	Font sizes (height)	
	Shown	Range
Title	120 (30 mm)	90–144
Heading	60 (15 mm)	30–90
Subheading	30 (8 mm)	30–60
Text	24 (6 mm)	16–30

[a] *All examples are in Arial style.*

Originally published by Davis et al. (1992) in J. Nat. Resour. Life Sci. Educ. 21:158.

be easy to read from the customary standing position of the viewer. The title needs to be legible from a distance of 5–10 m and the text 1.5–2 m. Readability depends on the size and style of type as well as line spacing and length. Size is measured in points relative to the height of letters. Blocky, thick styles of letters no less than 30-point for headings and 16-point for text will accommodate the requirement for legibility (Table 17.1). Certainly, the size of the display board influences how large you can make the type.

Also important are the length of lines and spacing between them. Adhere to Woolsey's (1989) admonition of no more than 65 letters and spaces per line, and lines spaced at one and a half are better than single or double spaced. As in Figure 17.4, lines that are justified only on the left are easier to read than with the added right justification. Common type faces that are good for titles include

Arial, Helvetica, Tahoma, or similar ones. For the text, most of these are good, or you may choose a conservative serif type such as Times New Roman, Bookman, Old Style, or similar styles. Avoid ornate or script styles, and use italics only where grammatically or scientifically required. Lowercase letters are easier to read than all capitals. As O'Connor (1991) and others suggest, you should use capital letters only where they would be used in conventional texts. The principle of giving the audience what they expect holds true here; our eyes are accustomed to lowercase, with portions of some letters extending below lines and to different heights above the lines.

17.5 COLOR AND PHYSICAL QUALITY

Color, depth, quality, and texture of materials can contribute to the physical appearance and the communication of the poster, or such features can serve as distractions from the scientific message. Refer to Imhof (2007) for principles of communicating with color (see Appendix 12). As he suggested, in general, subdued colors are more comfortable and bright colors should be used only for highlighting. I once saw a poster at a professional meeting that was predominantly bright red. I approached the presenter and, after a friendly question or two, asked her why she used red. She proudly proclaimed, "Red means stop as in stop light. I mean for people to stop at my poster." I agree that red sometimes means stop, but with that poster, as at a stop light, I intended to go as soon as I could. Brilliant colors are just not conducive to comfort of the eyes. Background color for the text and the illustrations should be a very light color or white. Off-white, beige, parchment, or other similar light color is comfortable for the eyes. Onto this background can be put almost any distinctive dark hue, but for text and tables, the conventional color that will not attract attention to itself is simply black type. Sometime highlighting with a bright color on a table or figure can emphasize a point you wish to make. However, remember that excessive highlighting simply negates the concept of emphasis. For figures on the light or white background, use distinctive, but not overpowering, colors to represent data especially in bars and lines or sections of pie charts.

Too many colors on one poster are distracting, but color can be used as a point of unity to code portions of the paper. Two different points, objectives, or experiments may carry two different but related colors (e.g. blue–gray and blue–green) throughout the poster to code them as separate but related sections of a unified whole. Color is best used when a purpose beyond that of simply attracting attention is evident. Poor or inappropriate use of color is especially noticeable in posters. Too many, too brilliant, too pale, or uncoordinated colors distract from the scientific communication in a poster as sure as a clown suit or gym shorts would distract from the words of a speaker at a scientific meeting. See Chapter 14 for further discussion of color.

Part of the use of color depends on the construction of the poster. Outlining sections of the poster in subdued color or lightly shading some backgrounds to

texts or tables with subdued colors can help to set them apart and add emphasis to main points. Be sure the coloring does not suppress the text, and use a consistent color throughout or no more than two colors if you need contrasts. Avoid bright colors except for very limited highlighting. You will likely have colored photographs. Coordinate the lines, frames, or background colors in the poster with the predominant colors in photographs you use.

As with slides, some authors have tried reversing the dark type and light background so that the background is a very dark color and the text is white or light. This unconventional technique can attract attention, but the attention may be to the unusual use of color and not to the content. Also, unless the contrast is entirely clear, the text can be difficult to read and the scientific message may be lost. Anything that makes the poster more difficult to read or comprehend should be avoided, even if it is artistically innovative.

Authors also sometimes enlarge and subdue a photograph related to their subject and use it as the entire background. On the surface, this idea appears to be a creative one. However, I have seldom seen the idea used successfully for two reasons: (1) The background can distract from the text and data that carry the scientific message, and (2) the background is almost invariably composed of multiple colors or shades of dark and light sections and lines that make it difficult to read some text printed on it. Both these drawbacks are serious limitations in good communication and appear to have little purpose in communicating the science. Also, sometimes it is difficult to determine what the image is, and your audience may be distracted from your content by trying to determine what it represents. Of the dozens of posters I have seen with photographs for backgrounds, fewer than a half dozen were well done, and even those offered no clear benefit from having the image present. The pale photo does not clarify the objectives, illustrate methods, or support results and conclusions. Although it is subdued enough not to interfere greatly with the text, the subdued background on Figure 17.4 is not helpful in any way for understanding the poster. Good judgment relative to color, sizes of individual pieces or sections, spacing, and arrangement of materials is extremely important for any method of construction.

17.6 SPACING AND ARRANGEMENT

Before you attempt a layout for your poster, find out the exact dimensions of the display board that you will be using. Then construct and print the sections on the poster sheet so that they do not crowd each other or the edges of the board. Communication can be enhanced by the sizes and shapes of the sections as well as their positioning on the board. Too many small pieces can give a "busy" appearance to the composition, but one large block with all the blank space at the periphery can be equally unattractive. Blank space is important. Woolsey (1989) has said that ideally 50% of the poster should be blank.

This blank space can be used effectively to separate parts of the poster and to communicate relationships among the parts.

Woolsey (1989) suggests that "the eye looks for edges." Too many edges or small pieces positioned together or separated with framing or space tire the eyes. To avoid extra edges, place subheadings or captions for figures and tables in the same frame or box with the accompanying text or illustration. Shapes that are not expected (triangles, jagged edges, or cutouts) attract attention to themselves. As with highlighting, an unusual shape used effectively may contribute to the communication, but overuse or inappropriate use will simply distract from the scientific message. Shape and arrangement of parts as well as size and color can serve to draw attention to points of greatest importance, to subordinate secondary material, and to unify the entire poster. With use of conventional headings (e.g., Objectives, Results, and Conclusions) and with parts of the poster grouped logically and unified with color and spacing, the viewer should be able to follow a logical flow of information.

17.7 PRESENTATION OF DATA

Points of unity and the relative importance of parts of the poster also apply to the presentation of data whether it is in tabular or graphic form, and any illustration should be placed near and appropriate to the textual content with which it is associated. Size and spacing in a table with a limited number of data points can effectively convey a scientific message. Ideally, a table for a poster would contain fewer than 12 to 16 items in the field. Highlighting with color can draw attention to an important column or item in a table, but avoid overuse of this attention-getting device. Be sure to follow the basic principles for constructing tables, and consider that they should communicate, or stand alone, without the text or the author having to explain meanings. See Chapter 11 on presenting data.

Similar principles are true for graphs. To emphasize a point, the number of lines or bars in a graph must be limited. No more than three or four lines or six to eight bars are best. The main point that the data carry should be illustrated as clearly and as simply as possible, and any additional supporting data or subpoints should be reserved for the oral discussion or for a journal manuscript. Color and size in graphs are very important. Too many colors and sizes are confusing. As in other communications, it is important to maintain consistency in labeling from one graph to another. If a point is represented by a color or shape in one graph, the same color or shape should be used to represent that point in other graphs on the same poster. Briscoe (1996) is very helpful in demonstrating design and construction of illustrations, graphs, and photographs.

Photographs will help to make the poster attractive and serve as relief at breaking points in the text, but those used should carry an additional purpose in

the communication. An appropriate photograph can help the title to convey the subject of the poster or can illustrate visually what the data mean. For example, a photograph showing a control and a treated plant may show the effect of the treatment more dramatically than numbers or lines could. Photographs, like other illustrations, need to be clear and large enough (at least 5×8 in. or 6×10 in.) to be immediately comprehensible and make a point relative to the scientific message. Be sure the point you wish to make with the photograph is in focus and obvious. Too many or undersized photographs contribute too many edges for the eyes. A matte finish is probably better than a glossy finish for most exhibition rooms, in which lighting is usually bright.

17.8 THE PRESENTER

The relative informality of the poster situation should not relieve a scientist of the responsibility for clear communication and a professional attitude. Your knowledge of the subject, your candor in discussing the science with others, and your appearance and attitude are important to the presentation. The professional meeting will offer many distractions for you as well as your audience. It is your responsibility to be with your poster whenever you are scheduled to be; some of your audience will make a point of being there to talk with you. You may also face the distraction of friends and acquaintances stopping by to chat about things other than the poster. Let your poster audience take precedence over the social audience. Quickly make arrangements to have the friendly chat later, and go back to the poster audience.

There may be periods when no one approaches your poster, and you feel that you may as well leave. Not so. Audiences are likely to appear one or two at a time. Masses of people will not flock to your poster. One important attraction of the poster technique is that the audience is limited to only the truly interested. If your poster adheres to the criteria for a good poster and if a few people read most of it and talk with you, you have been successful. Whether the audience is one or a dozen, execute your professional role with clear communication, knowledge, sincerity, and amiability.

17.9 HANDOUTS

A simple handout can enhance the poster presentation. The authors' names, e-mail addresses, and phone numbers should be available below the poster title or on an available business card. If you use a business card that carries a university, agency, or company name or logo, be sure its contents adhere to the policies of that establishment. You may also have available an abstract or other information about the poster, a list of pertinent references, an important method, or a table or figure that may prove valuable to the viewers after they leave the meeting. Some presenters supply a small, but readable, printout of the entire poster. When you provide handouts and before you release the material,

consider such matters as copyright, patents, and your own publication of the data. Unfortunately, not everyone is entirely ethical in their use of the intellectual property of others (see Chapter 12).

17.10 TIME AND CONSTRUCTION

In constructing posters, time is the antagonist. As you conduct your research, keep in mind that you may need to construct a poster in the future. Take photographs for prints and isolate the data that you may use. Weeks before your poster presentation, select possible photographs to use, set up tables and figures, and write the text. If you also need to be working at other tasks, allow yourself at least 2 or 3 weeks after a draft of the text is ready to put the poster together. Allow time to reconstruct after reviews; produce final copy several days before the meeting and only after reviews and revisions are complete.

Familiarize yourself with the software that will allow you to print your poster on one large sheet and study what that software can do, but guide the process carefully. For example, across a wide sheet of paper, you could print a single line of type that is a meter long. Several lines that long are difficult to read. Stick with the idea of no more than 65 characters and spaces per line. Take time to arrange all the materials on the single sheet in logical and easy-to-read form; this work may require some rewriting of text that will not fit a column or omitting a picture that you wanted to use. A rush job will produce a poorly worded or poorly arranged poster. It is a good feeling to be ready a few days before departure to the meeting. The single sheet can be rolled carefully and packed in a tube. Be sure to pack any pins or adhesive and other materials you may need to mount your poster. If you fly to your meeting, carry the tube with you; do not check it. It might not arrive at your destination when you need it. Check the airline policy regarding carry-on luggage to be sure your tube will not be declined at check-in. Also, prepare for the worst case scenario and, before you travel, locate a print shop close to your hotel that can quickly provide you with another copy of your poster.

Several sources of information are helpful in learning to design and display posters. Basic principles in visual communication that are valuable not only for posters but also for other visual displays can be found in Briscoe (1996). Gosling (1999) provides information on the design and construction and the use of color in posters. He gives examples of blunders that have been made by not being attentive to good techniques. His book is somewhat dated and presents information that was good for construction before the widespread availability of printers that could produce single large poster-sized sheets, but the fundamental principles for designing posters are the same whether posters are produced as one sheet or mounted in individual pieces. Other less extensive information on the poster format is that of Woolsey (1989), Hofmann (2010), and Peterson and Eastwood (1999). Other suggestions and specific details for posting and presenting are typically available from societies that use posters at their meetings.

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Chapter 18

Group Communications

The true spirit of conversation consists in building on another man's observation, not overturning it.

—Bulwer Lytton

Group communication demands that you speak at appropriate times but that you listen as much as or more than you speak. If half of communication is listening, then obviously when more than two people are involved, each will speak less than half the time. That is not to say that all the time is divided equally; the division will depend on the roles individuals play, but the most important point is to listen well. Keep in mind that listening involves observing and processing messages as well as hearing the words, and those messages are highly influenced by body language and tone of voice. Indeed, much of communication comes from nonverbal communication throughout a group. Gestures, facial expressions, voice tone and quality, and looks exchanged between group members carry much of the message.

Listening is more difficult in a group than it is with an individual. Much has been written about group dynamics and the complexity of this semantic environment. You must quickly shift from one personality to another and synthesize diverse messages with your own ideas. Beware of your own nonverbal communication and how others are interpreting it. This complex arena of group interaction is one of the most vital in maintaining and building a professional reputation for you and critical for conducting research, teaching, or other business in the world of science.

Communication, problem solving, and decision making with a group demand that you be a true professional through service to others by reaching professional, and not necessarily personal, goals. You should be ready to leave many of your self-interests behind and work for the good of the group. In our Western culture with our attitudes of independence, this mind-set is difficult to hold. However, whether you work for a private industry or a public agency or institution, you will find yourself involved with group communications. Although some believe that more time is wasted in group communication than with any other format, solving a problem or reaching a decision can benefit from a well-planned and well-executed group discussion wherein individuals assume their roles professionally and communicate skillfully. As Beebe and

M. Davis, K.J. Davis, M.M. Dunagan: Scientific Papers and Presentations, Third edition.
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Masterson (2011) proclaim, “The quality of communication really affects what a group accomplishes.” Organizing a meeting as well as preparing for and carrying out communication with a group depends to a large extent on whether or not the meeting involves an audience beyond the group itself.

18.1 GROUP COMMUNICATION WITH NO AUDIENCE

You may be asked to serve with closed groups to make plans for research projects, to decide policy, or to evaluate a fellow employee’s progress. These professional duties are usually performed without an audience and in the format of a roundtable discussion or a board or committee meeting. The roundtable discussion is informal. Its purpose may be for brainstorming and professional sharing of ideas with no formal agenda followed and no decisive outcome expected. It can be very beneficial in initiating and sharing ideas, but it generally falls short of reaching any conclusion to an issue.

A board or a committee is a more formal, small group selected from a larger organization to assume a given responsibility. Participants follow agendas and expect outcomes that are usually reported to the larger body through their leader. Standing committees serve for indefinite periods; ad hoc committees are set up to deal with one particular job and are disbanded when the job is complete. Definitions begin to overlap with the use of the term **task force**, which is a kind of ad hoc committee but is usually made up of experts in a given area whose job may require a great deal of time and a detailed investigation for coverage of an issue.

Whatever format is used, professional ethics dictates that you perform actively to the best of your individual ability to accomplish the group’s goals (Wilson and Hanna, 1993). Sometimes individuals are appointed to serve in such roles as chair, recorder, or even a devil’s advocate to search out problems. Often, a group selects from among themselves the persons who will fill such roles, or a person may assume a role of leader or antagonist without being officially named to the position. Once the group is selected, the ultimate task with no audience involved is often decision making or problem solving.

Decision making involves alternatives. Defining the alternatives may require research and discussion. Making the best possible decision can depend on gathering information and even solving problems along the way. After discussion of the advantages and disadvantages of each alternative, the group should reach a consensus or conduct a vote to make a final decision. Much decision making is preceded by or mixed with problem solving.

Problem solving may begin with no obvious alternatives. The best solutions can be reached with a step-by-step procedure. As with the scientific method, we begin with a problem, identify or define it clearly to all members of the group, gather data, analyze that information, synthesize the new information with what is already known, reach a solution, and evaluate the outcome. Reaching a solution in a group involves coordinating the expertise and opinions of several minds and personalities. The group has the advantage of dividing workloads

BOX 18.1 Procedure for Group Problem Solving

1. The problem is clearly defined and objectives are set forth and understood by all members of the group.
2. Members as a group plan their individual and collective actions. They may divide responsibilities for gathering information and offering opinions.
3. As individuals and as a group, they devise a plan of action.
4. They act on the plan and make a decision.
5. They implement their decision and analyze outcomes.
6. They evaluate the results of their actions and determine whether the solution was acceptable.

and contributing multiple kinds of expertise but the disadvantage of coordinating diverse opinions. Recognizing these conditions, the group must follow essentially the same steps as the individual would follow (see Box 18.1).

With the group, as with individual problem solving, a poor solution to the problem can result from inadequate or faulty information or poor communication. Each step in the process must be fully executed in order that the next step can be successfully achieved. Groups sometimes get in a hurry to reach the goal and fail to define the problem fully or do not plan their actions carefully before they proceed. Without deliberate planning, members of the group will begin to stumble over their lack of understanding or the sequence of actions and must then return to the definition of the problem, explain it, and map plans all over again.

The size of the group and the time given to accomplish a goal are crucial to success. A large group of 10 or more people will have trouble involving all the personalities and effectively communicating the individual ideas. Some individuals may sit with the group but offer no suggestions and simply allow others to make the decisions. A smaller number in a group puts a greater sense of responsibility on each individual. Also, the choice of an odd number can avoid an impasse by forcing a majority in a vote. Cragan et al. (2009) say 5–7 is an optimal number "for any type of work to be done" in a group, 3 is minimal, and 13 is maximum. Keyton (2006) agrees that 5 is the optimum number for a decision-making group but that often more members must be included. When many members must be included, clearly dividing responsibilities among individuals or smaller groups can be helpful. Planning contributes to effective use of time, and the combined expertise of the group can make use of additional time worthwhile when all members maintain some enthusiasm for the work they are doing and communicate professionally.

If your group is too large, brainstorming is one way to initiate progress. The intention of brainstorming is not to solve the problem but, rather, to generate ideas that can lead to a solution. An advantage of this technique is that ideas need not be criticized at great length but presented only for consideration. The entire group might brainstorm until they reach a consensus on which ideas to discuss,

but if many personalities are involved, the less assertive members of the group may be intimidated and fail to offer their opinions. To ensure that all contribute, the large group can divide into smaller groups for preliminary discussions and then present their ideas and objectives to the full group. Another brainstorming technique for handling a large group is to ask each participant to write on a card or slip of paper what he or she believes are the most important ideas to consider. Better yet, ask each to come to the meeting with this information already prepared. Then a recorder or leader can present all these ideas to the entire group. From the list, ideas can be combined and reorganized, and priorities can be established. When specific topics or objectives have been filtered from the random ideas that evolve during brainstorming, then the critical process begins.

Members of a group charged with the task of problem solving or decision making often are people who already have a full load of responsibilities, and this group assignment can be frustrating. They may determine that it takes too much of their time, and they will just allow the rest of the group to research the problem and make the decisions. If the problem or decision is one that affects all involved, including you, it may be unethical not to do your part. It is certainly unprofessional to not participate after you have agreed to serve with a group. Yes, you may believe that it takes too much of your time, but it takes too much of the time of others also. It may be that working systematically step by step and assigning particular duties to individuals will save time and the time spent will be worth the effort. I have found that group problem solving is often almost impossible or poor solutions are reached when individuals assume no specific responsibility and the group has meeting after meeting with random talk but little organizational progress. Brainstorming ad infinitum will not accomplish a purpose.

Positive progress can be made only with thorough, critical analysis by individuals who, in turn, skillfully communicate with the group. As a member of the group, you should assume any assigned responsibility and research whatever information is pertinent to the decision making, the problem solving, or the presentation of information. You shirk an ethical and professional responsibility if you come unprepared to participate fully. When individuals do not assume individual responsibility for preparation, information, and participation, the group interaction can often degenerate to confusion or, perhaps worse, to a point where individuals are not thinking for themselves (Figure 18.1).

Janis (1982) coined the term **groupthink** to apply to a mentality of group agreement without the individual minds sorting out the best decision or solution to a problem. "Groupthink is the illusion of agreement—a type of thinking that occurs when a group strives to minimize conflict, maximize cohesiveness, and reach a consensus without critically testing, analyzing, and evaluating ideas" (Beebe and Masterson, 2011). Generally, a group should be cohesive and avoid the kinds of conflict that are destructive and disruptive, but healthy conflict and debate conducted professionally are important to decision making or problem solving. Passive group members may believe they are being cooperative and

FIGURE 18.1 Groupthink involving too many passive minds does not provide the best solution to a problem.

agreeable when, actually, a devil's advocate who challenges ideas and proposed solutions would be more valuable. With open, critical, professional discussion and debate, the best ideas can be sorted out over time and the appropriate conclusions can be reached. Groupthink may be the result of apathy or of a reluctance to disrupt or persuasion by a strong individual in order to go along with the group despite the person's belief that the wrong decision is being made. It is good to be agreeable; it is bad to agree to the wrong solution.

The group effort is no better than the composite efforts of the individuals in it. If the decision made is one that affects the entire group and perhaps many other individuals in a company, agency, or institution, one must put group benefits above personal benefits. "Every man for himself" is not a motto to follow. In working with a group, be critical and cooperative at the same time. A professional can be critical of ideas without being critical of the people offering those ideas. Listening is of utmost importance (see Chapter 14). Cooperation and professionalism demand that you be open-minded, listen as well as talk, and give and take opinions; they often require that you allow your ideas to be questioned, carefully consider the ideas of others, and are willing to compromise on points of disagreement. The passive power of groupthink can obliterate the best possible ideas. Unanimity in decision is a good quality only when all ideas are shared and the decision is truly accepted by all members of the group. A decision should be strong once it is made, but it is an end, not an objective means, and the means does not justify the wrong end.

18.2 GROUP COMMUNICATION WITH AN AUDIENCE

Individual responsibility is important whether or not your group is working with an audience. An audience adds another dimension to the semantic environment. Members of the audience are active participants even if they only listen. With the audience involved, group communication can take several forms. Often, the program for a professional meeting includes a panel discussion, a symposium, or a forum. The panel discussion, carried out by a small group in front of an audience, is often unrehearsed but need not be unorganized. The panel employs informal discussion with a leader to moderate the communication. It may appear to be spontaneous, but that appearance is usually the result of careful planning. A symposium is also made up of a small group, but participants act as individuals, with each making a prepared speech before the audience. Their speeches are on the same or closely related subjects. The symposium is more formal than the panel discussion and may have little or no discussion among the participants. A symposium often turns into a panel discussion among the speakers or a forum or question–answer period with the audience. A forum involves all the attendants at a meeting; that is, the total audience is involved under the direction of a leader or leaders.

When an audience is involved, the planning for group communication is again extremely important. Every group participant must clearly understand his or her role and how much time is allotted to the entire program and to each participant. It is equally important that members of the audience understand their role. Can they ask questions or make comments during the discussion, after the discussion, or not at all? Before any discussion of the topic, a good moderator or chair will explain to the audience and the participants the goals, procedures, and individual and group roles. These roles in a panel discussion can illustrate the responsibilities.

18.2.1 The Panel Discussion Leader

If you are in charge of the panel as chair or moderator, *before* the meeting you will need to carry out several duties:

1. You may be responsible for choosing the panel members. Choose carefully. Participants should have expertise on the topic to be discussed; they should be articulate and capable of presenting organized information. If a subject is controversial, they need to be able to maintain a professional attitude that does not allow for emotional outbursts or argumentative assaults on other group members. In other words, when you select participants, carefully evaluate their expertise, professionalism, and communication skills. Although you may rightfully have your own bias about a subject, suppress your own views temporarily and balance the membership of the panel so all sides of a question are given equal consideration. Such diversity can be valuable if everyone keeps professionalism foremost in their attitudes, but two conflicting personalities with two

conflicting opinions can create a problem if both parties cannot conduct the discussion in an open, calm, and professional manner, especially if the discussion leader also demonstrates a bias. If panel members have already been selected and you are asked to chair them, study their personalities and expertise before the group convenes. Then guide them toward a common goal.

2. After you have chosen members of the discussion group or have accepted leadership of a group already chosen, you need to be sure all members, especially you, understand the purpose and the objectives to be put forth and accomplished. You may wish to consult with each participant for ideas to incorporate into the program. Study these ideas and your own carefully in view of the objectives and plan a strategy for conducting the panel discussion. Organize topics to be discussed around the time you have allotted.

3. Once your members are chosen and your plans are clear to you, be sure each of the participants agrees not only to the objectives but also to the procedures, timing, and the role he or she is expected to play. Talk with each personally if possible, and send each an agenda or outline of the program with names and roles of all participants.

4. Consider the external influences on the semantic environment. These include the audience, the room, and other physical conditions; the time involved and how portions of time should be allotted; and any other condition that could influence the success of your meeting. Sometimes bad weather, noise next door, time of day, or temperature and lighting can impede an otherwise successful plan. Even the arrangement of the chairs in which participants sit will influence the meeting. A curve-shaped arrangement in front of the audience is often better than a straight line. Most people are more comfortable sitting behind a table that allows space for notes and armrests. The room can be too large or too small, microphones may be needed, or your program may overlap in time with other sessions of interest to the audience. Your audience may be sleepy or discontent. Be flexible in case of unexpected occurrences, but to whatever extent these things are under your control, control them.

At the meeting, it is usually your responsibility as leader to take charge of the environment. Arrive early and take care of final details in the physical setting and greet the participants as they arrive. Your own confidence and relaxed attitude can be contagious. Carrying out the communication smoothly will also depend on how well you follow the organized plan. As leader, consider the following responsibilities *during* the meeting:

1. Introduce the session to the group and to the audience. You will introduce the panel members to each other before the session begins if they are not already acquainted and to the audience as a part of your introduction. Then, you will outline the objectives for the discussion to both the panel and the audience. At this point, be sure that members of the audience understand the role they are to play. Let them know whether you invite interruptions or prefer that questions and comments be saved until panelists have completed their initial comments. If you are concerned that the audience will be too vocal, you may wish to ask

them to save their comments or questions until the end of the panel's discussion or to submit any questions they have in writing (perhaps on cards you provide). A smooth beginning can establish a rapport with the audience and contribute to a successful program. Despite your careful planning, when an audience is involved, be ready for surprises.

2. Your duties as leader during the session are to participate, moderate, arbitrate, evoke discussion, keep discussion on the topic, and summarize at appropriate junctures. Encourage all panelists to express their views; prompt the more timid with questions, and pull the conversation away from the aggressive talker. If an individual tries to dominate or if the subject gets off track, interrupt the discussion, summarize the points that have been made, and redirect the group toward a question or a new point. If the discussion becomes too nebulous or general, tactfully call for details to support statements being made. In a relatively long session, it is good, even if the group is staying on track, to inject a summarizing statement more than once. This kind of control may be important in order to keep the program within a designated time as well as to be sure all issues in the original plan are discussed. Caution: In your role as moderator or leader, do not monopolize the situation. Many leaders become too aggressive; it is your responsibility to guide and encourage the communication, not to subdue the group and do all the talking yourself. You are the host; the audience came to see and hear the entire panel.

3. You will also be responsible for concluding the session. Again, summarize the points discussed and any conclusions that have been reached. Often, you will need to reiterate the objectives and show the extent to which they have been fulfilled. It will be important to include in your summary those unexpected points that arose during the session. In other words, you cannot completely plan your concluding remarks before the session begins; you must take notes throughout the discussion and quickly organize and present major points that were brought out. The job of concluding will be easier if you carried out your other responsibilities effectively.

Finally, in ending the session, you will include an expression of appreciation to the panelists and to the audience for their attention and participation. If further sessions are to be held or announcements made, you may be in charge of information about those. Always conclude with a professional and pleasant attitude as leader, even if the discussion itself has deviated from those qualities.

18.2.2 Responsibilities of Group Members

Leadership skills are essential for every panelist. Members must consider the audience, the individuals involved in the discussion, the objectives and plans for the meeting, the time involved and how much of it belongs to each of them, and the professional attitude essential for a successful meeting. As a member, you may be expected to take the lead on certain issues or you may be in charge of a segment of time. Often, the designated leader or moderator may be put into

an uncomfortable position by a question from the audience or a point being discussed about which he or she does not have expertise and is expected to voice an opinion. At such a point, a panel member can supply the needed support to keep the discussion on track by injecting an apt comment and unobtrusively assuming temporary leadership. Relinquish that role as soon as possible.

18.2.3 Responsibilities of Panel Members

1. Define, interpret, and analyze the subject and points that arise.
2. Keep the discussion relevant and lively.
3. Evoke discussion from each other and, if applicable, from the audience.
4. Control unproductive conflicts and give each group member equal opportunity to participate.
5. Give each issue appropriate time and attention.
6. Follow plans set forth in the preparation for the meeting.
7. Help summarize the issues at various points along the way.
8. Assume leadership on particular issues and maintain a professional attitude throughout.

18.2.4 Planning for Discussion Groups

Organization for group communication includes the subject matter, time, place, and people involved. The following are possible structures on which you might base your plans for a group discussion. These examples apply where both a small group and an audience are involved, and they are certainly not inclusive of all possibilities.

18.2.4.1 The Forum

For a forum led by a panel, in a short statement the chair may introduce the subject to be discussed and outline the goals to both the panel (who should know already) and the audience. This leader of the panel then opens the discussion. This technique turns into an open discussion among audience and panelists, or it becomes a question–answer session with the panelists serving simply as leaders answering questions and discussing issues along with the moderator. The method is valuable for public meetings where experts are invited to serve as a panel of consultants. The danger in this structure is the difficulty in controlling a large group, especially if an issue is emotional or controversial and the audience or the panel includes some aggressive, opinionated personalities. All panel members need to help control the situation with careful consideration of their own attitudes and remarks and move toward the prescribed goal in a professional manner. The leader should be a strong individual who does not allow the meeting to get out of control. Control in such situations comes more with finesse than with demands. Strong opinions can be good; anger mixed with strong opinions is devastating to any discussion.

18.2.4.2 The Panel

The chair may introduce the general subject in a short speech and then turn discussion over to the panel with no audience involvement except for listening and thinking. This technique is often used with television or radio broadcasts. The chair keeps the issues moving by asking questions and by directing and redirecting the discussion from panelist to panelist in an equitable manner. If a live audience is present, its members may insist on being involved. Panelists should be careful not to encourage audience involvement. Again, a strong leader must tactfully assert his or her position, outline the plan to the audience from the beginning, and divert any interruption that could keep the meeting from reaching a goal.

18.2.4.3 Symposium/Panel/Forum

A symposium can turn into a panel discussion followed by a forum with total audience participation. The chair may introduce the general subject and the basic issues to be discussed. Then group participants or selected members may make short speeches in which they outline issues or points of view. To this point, the format is that of a symposium, but it may develop into a panel discussion, a forum, or both after the short speeches.

As much as possible, decisions on which direction the meeting will take should be made before the meeting. Leadership roles may be divided among panelists by subject matter or points of view, and each must assume responsibility for moving toward a common goal. Audience involvement may require that the leader serve as moderator between the panel and the audience. The symposium that develops into a panel and forum is valuable for controversial issues or for subjects that should be considered from several points of view. Success depends on a controlled, professional atmosphere.

Whether or not an audience is involved, prepare and organize materials for any group communications as carefully as for individual presentations. A great deal of time can be wasted if leaders are not prepared with a plan for conducting a meeting and if participants have not consulted that plan, organized their thoughts, and prepared supporting materials to express their views. A surprise item on an agenda can be most disrupting. Group members need time to consider an issue before discussing it. Keep in mind the following important points that can make any group communication successful:

- Set a specific goal but keep plans simple. Be certain all member of the group have been presented with the goal and plan before the meeting.
- Start on time, give each issue appropriate time, and end on time. With group interaction, you need to limit what you can accomplish in a reasonable time.
- Be sure everyone, including any audience, knows what format is being followed and what goal is pursued.
- Think as an individual; think before the meeting; offer critical analysis and clear evaluation of information discussed; avoid groupthink.
- Work toward the prescribed goal, summarize along the way, and avoid digressions.

- Maintain a professional attitude and cooperate with the leader and other participants.
- Sustain equitable participation; do not talk too much or too little.
- To the extent that you can control such things, be sure the physical situation is comfortable for everyone and conducive to good communication.

18.2.5 Virtual Communication in Groups

Recent technology has provided us with discussions and conference calls that may or may not allow us face-to-face exchange with other members of the group. This virtual communication has great advantages in overcoming physical distances between group members, but as with other electronic introductions into communication, it can involve adjustments in listening, speaking, and writing skills. Cragan et al. (2009) define the virtual team as "a task-oriented group that can collaborate across time, space, and organizational boundaries by harnessing the power of computer-mediated communication." As technological systems improve and increasingly more people become adept at using these systems, group communication will benefit from not being bound to the time and location where a group can meet physically. However, much of the face-to-face communication skills and interactions of the group may be lost. We have to accept and use the benefits and compensate as much as possible for the losses. Another tool has simply been added to our communication ability just as the telephone, telegraph, and fax machine were added in the past.

For many of us, e-mailing is an everyday activity, and we are constantly adding online classes, discussion groups, web conferences, video conferences, and other social and professional avenues to our communication. You may find yourself in a group that mixes face-to-face meetings, or perhaps an initial introductory meeting face to face, with further meetings or communication exchange via computer. You may find yourself interviewing for a job via conference call with a group. Conference calls may allow a member of your graduate committee to attend a meeting at your school while he or she is thousands of miles away. All these things can be beneficial, but we have to harness the advantages of the fundamentals of communication in order to accomplish our goals.

Not having an in-person view of body language can be a handicap, but much can be expressed in the voice with tone, enthusiasm, and enunciation. As in all group communication, listening well is paramount, but without a visible face behind the voice or one that is semi-obstructed by a bad Internet connection, meanings can be incomplete. Let me suggest some points to consider. Be sure a compatible technology system is used by all members of the group. Agree on ground rules before beginning virtual communication. Be on time, do not talk too much or too little, be professional, listen carefully and respond courteously, and take turns with talking. Two people talking at once or attempts to talk over one another can be totally ineffective. Watch your language carefully for meanings and potentially alternative interpretations. It may be more likely that someone who does not see that twinkle in your eyes will interpret a humorous

message as negative, sarcastic, cynical, or prejudiced. It is equally as important to watch out for slang, jargon, excessive abbreviations, incomplete sentences, abrupt remarks, and even misspellings in an e-mail or text message that can influence interpretation. In other words, it is essential that you learn to use these new tools effectively, base your use of them on the fundamentals of good communication, and use them well. Make them a good thing for group communication as well as for personal or individual communication.

Throughout their book, Beebe and Masterson (2011) repeatedly include short sections on virtual communication with the various issues involved with group communication. Cragan et al. (2009) dedicate an entire chapter to the subject. Apparently, a great deal of research is being done on this topic. Keep up-to-date on how best to communicate virtually. Whether they are face to face or virtual activities, the group structures I have discussed clearly do not exhaust the creative possibilities, and your choice of format for communication may depend on the subject, how formal or informal you need to be, how much time you have, and at what point you wish to involve an audience. Whatever the situation, perhaps the most common group communication for the scientist is with a team of fellow researchers.

Whether it is a committee appointed to recommend a company policy, a panel of experts discussing an issue before an audience, or a team of scientists discussing a research discovery or project, the principles that take group communication to a desired goal are the same. Your participation should be active and ethical. You can work effectively with the diverse personalities in your group if you assume a high level of professionalism and acknowledge the rights of others. Think independently and respect the independent thinking of others, even those who disagree with you. Recognize that in your work as a scientist, you will need to develop some skill with group communication. If you have trouble working with a team and especially if your work involves a great deal of group communication, take a course in group communication or, at least, study Beebe and Masterson (2011) or refer to texts such as Keyton (2006), Cragan et al. (2009), and Wilson and Hanna (1993).

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Chapter 19

Communicating with the Nonscientist

We have a society exquisitely dependent on science and technology, in which the average person understands hardly anything about science and technology. This is the clearest imaginable prescription for disaster—especially in a purported democracy.

— Carl Sagan

In your scientific career, one of your most serious responsibilities is to communicate clearly with those who know little about your area of expertise. The medical doctor, the science teacher, and the practicing scientist in the U.S. Extension Service face this responsibility almost every day. Communication with the nonscientist is a major responsibility of the soil scientist, who must explain to a home owner or construction engineers the ability of the soil to accommodate a building or a septic system, and of the environmental consultant, who must explain to city leaders the conditions needed for waste management. The primary responsibility of the public information officer or the journalist who works as a science editor is to explain discoveries to the public, and scientists must sometimes lobby politicians to obtain government funds for research. Almost all other scientists should also use a portion of their time and effort to serve as links to the multitudes of nonscientists.

We sometimes complain about scientific illiteracy among the public, but not everyone can have a college degree or specifically a degree in science. A specialist in the arts and humanities has no more time for studying sciences than the student acquiring an education for scientific research has for studying art and history. But then, every artist should have some knowledge of science, and every scientist should have more than a cursory knowledge of the humanities. A little learning can be a dangerous thing, and as Will Rogers told us, "Everybody is ignorant, only on different subjects." It may be that those who are scientifically illiterate have not taken advantage of educational opportunities or have just enough learning to be confused. It also could be that scientists do not provide them with adequate opportunity to acquire unbiased knowledge. Keeping scientific information enveloped in an aura of mystery is not in the best interest of society or science. Any good scientist can attest that the unknown elicits curiosity, but it can also evoke anxiety and fear. As with other influences on our

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lives, science and technology involve risks. A responsibility of the scientist is to help the nonscientist acquire enough information to satisfy the curiosity and help calm the fear.

19.1 THE RESEARCH SCIENTIST

A few general concepts that actually apply to almost any communication are especially important to the research scientist who is communicating with the nonscientist. What has traditionally been referred to as basic and applied science cannot be separated. Discovery is important, but what you do with that discovery is equally important. The values we place on the applications of scientific discovery are extremely important to society. If you are a research scientist, who focuses primarily on discoveries and recommends applications for them, be proud of what you are and what you do. Progress in science is remarkable, and you want other scientists as well as the lay audience to care about your work. To reach these nonscientists, be open-minded about their knowledge and interests and see values from their vantage point whether you agree with them or not.

Human values are diverse and often conflict. Every discovery is laden with values that involve both risks and benefits. Medical breakthroughs are lifesaving, but sometimes the side effects are deadly. Science is not the only possible constructive truth in the world, and every scientific experiment is based on limited measures that do not reveal the whole truth. "Any single set of factors can be interpreted in a variety of ways" (Gould, 1981). Science has made possible both the good and the bad. Your belief in science can be firm, but someone else may believe as strongly that science is a wayward and destructive body of knowledge. Neither of you knows the full truth. Scientists are not amoral, and the products from science are not immune to other human values. Communication is the avenue through which you can reconcile differences so that those with differing opinions can work together for some specific good, whether it is learning more about the universe, protecting the earth's environment, or improving human health.

It is easy for the research scientist to ignore opportunities for communicating with nonscientists. As a researcher, you do not have time for auxiliary tasks that will probably provide little information for your research project or ammunition for your promotion. Besides, you have seen how "the public" can take a professional's words out of context and make distortions out of accurate remarks by putting them into a new context. Scientific issues, especially health and environmental issues, are not detached from politics and everyday life, which are often filled with misinformation. Public policy on scientific issues is often shaped by those whose area of ignorance is science. Political lobbyists or salesmen who may or may not be scientists themselves can have problems with rationalization and conflicts of interest relative to the companies or constituents they represent. Messages become distorted, but that is all the more reason to

make a decided effort to provide accurate information to the public. In a democratic society, anyone who knows about a subject should contribute to the quality and education of a self-governing citizenry. Theoretically, scientists should be the most objective, open-minded of teachers, but scientists have biases just as others do. Keep a high level of objectivity so your communication with the nonscientist is not influenced unduly by your biases.

Communicating with nonscientists is not only beneficial to society but also beneficial to science and to you. Your funding for research is more likely if the nonscientists who approve the grant can understand and appreciate your work. Your work can be carried forward to the next generation if you can gain the interests of younger people to go into the fields of science. I strongly recommend that, as a research scientist, you read Dennis Meredith's *Explaining Research* (2010). He offers convincing reasons for communicating with nonscientists and gives instructions on who, how, when, and where as well as why. One of the most important reasons, as Meredith says, is that if you do not explain your research, people not so familiar with it may explain it "in an uninformed way."

19.2 THE SCIENCE PRACTITIONER

Unlike audiences for the research scientist, the audiences for the science practitioner are more often than not made up of nonscientists. I define science practitioner as anyone whose career is chiefly involved with applying science and taking scientific information from the pool of scientific knowledge to the nonscientists. These practitioners include teachers, museum curators, educators at wildlife centers, consultants, and U.S. Department of Agriculture extension agents as well as a multitude of others. They may also do research, publish scientific papers, and speak at scientific conferences, but a great deal of the responsibility in such positions is to carry and apply scientific knowledge to the world in which we all live. They are our vital link between scientific discoveries and applications. This communication task is likely more difficult than that of scientists communicating science to scientists. The surgeon trying to explain a complex procedure to a patient and the teacher wrestling with explanation of photosynthesis to a youngster have frustrating responsibilities. The soil scientist explaining to home builders why a wetland on their own properties should not be drained and a biologist telling a timber company that certain forests cannot be clear-cut because of an endangered species may find no pleasure in delivering that message to the recipient of the news. Clear, accurate information delivered with patience and understanding of the audience's point of view is essential.

In the interest of the future of science and the physical world, the educator is probably the most important of all science practitioners. The classroom teacher needs to know the science and also needs to have the enthusiasm for extending it to students. The educators at parks and museums need to be able to take new people on the same tour they guided the day before with the enthusiasm to make

everyone excited about the physical world and its preservation. The college professor who guides a graduate student through an experiment must recognize that this part of his or her job is vital to the future of science. Also vital is the extension agent with the Department of Agriculture who advises the people who grow our food and fiber for our clothes. The nurse who carries a scientific discovery from the doctor to the patient is a critical link in the medical world. These practitioners make science functional for all of us.

19.3 THE SCIENCE WRITER

One particular group of science practitioners who dedicate most of their work to communicating with the public are science writers or communicators. Much more is said about science writing than about science speaking, but both are important, and together I call them science communication. Any scientist can and should be a science communicator. Definitions of words are often nebulous. Quarreling about the meanings of closely related words can be fruitless, and sometimes we have to make distinctions even in synonyms in order to use them to express differences in their connotations or applications. Therefore, we make a difference in meaning for “science communication” and “scientific communication” by suggesting that scientific communication is a matter of scientists exchanging information chiefly with other scientists. Science communication is done by scientists or journalists for an audience of nonscientists and involves different treatment and delivery techniques for a subject. However, most of the fundamentals of communication are the same. Except for the chapter on publishing in scientific journals and some specific references to or examples of scientific communication, the suggestions in this book are for any science practitioner as well as the research scientist.

As a scientist, decide how much time and effort to give to communicating with nonscientists. Certainly, science writing and presentations on science can constitute a career in themselves. For any of you who may be interested in such a career or freelance or part-time work in that area, read Meredith (2010) or the book edited by Lutz and Storms (1998), especially Chapter 7 by Ricki Lewis. You may want to investigate the National Association of Science Writers at http://www.nasw.org. Blum et al. (2006) edited *A Field Guide for Science Writers*, which is the official guide of the National Association of Science Writers. It contains commentary by well-known science writers about the media and audiences they write for and the subjects they write about. Also look at other examples of science writing, such as those of Zinsser (1988).

The research scientist and the science practitioner are both science communicators and either may play both roles in their careers. The semantic environment in which the communication is carried out makes the difference. This environment includes the audience, the purpose, the physical situation, the delivery techniques, and the communicator. Whatever career path you take as a research scientist or practitioner, you can find a way to convey some of

your scientific knowledge to others. You can fulfill your responsibility if you will think in terms of who makes up the audience, what avenues you have for reaching various audiences, how your subjects can interest them, and what techniques can best convey your messages to those people. Meredith (2010) is an excellent source of information on communicating with the nonscientist. If your career focuses almost entirely on being a research scientist, you can still find opportunities to speak to or write for other audiences.

19.4 AUDIENCES

The audience makes the difference in where, what, and how you communicate. How do you talk with or write for an audience that has no idea what deoxyribonucleic acid, trinitrotoluene, anthesis, or denitrification are? Above all, do not strut like a peacock simply because you know some words unfamiliar to your audience (Figure 19.1). You actually speak the same language they speak; you simply have acquired some alternative vocabulary that makes it more convenient to communicate with your peers in science. You should be capable of using a term such as "flowering" or "bloom" rather than anthesis or of referring to "TNT, a highly explosive material" rather than trinitrotoluene. Rather than tell third-graders that a certain plant and insect have a synergistic relationship, tell

FIGURE 19.1 "Excellent communication skills. Poor choice of words."

them that these two depend on each other to survive. If you cannot adjust your terminology with words appropriate for your audience, perhaps *you* have a literacy problem.

Selective vocabulary and jargon can also be detrimental in communication between scientists. I knew an advisor who told his graduate student just before a speech at a conference to "snow 'em with the terminology." He contended that because he and the student were working in a new area of research, the student should be able to string together a vocabulary that even the scientists would have trouble following and, thereby, "leave them impressed." I felt at the time that the advisor should be pelted with rotten tomatoes. In any communication effort, the objective is to make your audience understand, not to "snow 'em" with self-important, bombastic jargon. If you need to use new or unusual terms for an audience who might not understand, explain with examples and analogies.

Professors sometimes have trouble lecturing to a group of freshmen because it is difficult to assess their level of understanding. In speaking, watch your audience and observe any expressions that indicate whether they are understanding. When writing, keep the image of a typical reader in mind. For a basic understanding of your audience, you need to consider such characteristics as their ages and educational level. They may have never had an opportunity to attend college, or if they are PhD's in the humanities, they may never have taken science beyond a general biology or chemistry course. Most of them, however, are as intelligent as you. You need to think about their interests, their prejudices, their attitudes, and their occupations. Find out as much as you can about their needs, their biases, their familiarity with your subject, and their reasons for wanting to understand what you have to say. Paint a picture in your mind of the typical person in your audience. That person might have high regard for your scientific education and respect everything you say. Let that trust humble you a little. On the other hand, if the typical member of your audience has prejudices or a negative attitude about the values in science or the topic of your presentation, he or she has reasons for such notions whether or not objectivity is at the root of those reasons. Try to discover the reasons and respect them as much as possible while communicating as clearly as possible.

Your job will be relatively easy if the audience is a homogeneous group such as science club students from grades 6 to 8 or the chamber of commerce of a small town. More difficult is "the public" or even a college audience composed of graduate and undergraduate students from all areas of science. In your scientific paper written for your peers, you may say, or assume they know, that denitrification is the reduction of nitrates or nitrites to nitric or nitrous oxide by denitrifying bacteria under aerobic conditions with an available carbon source. You would be able to tell the advanced college science majors the same thing, but freshmen or garden club members might need some alternative explanation.

For the science writer whose work goes to the general public or for the extension agent explaining a scientific principle to farmers, your objective may be different. Your listeners probably do not need a scientific definition at

all; they need to understand why the scientific idea you are communicating is important to them. You may then explain that nitrogen fertilizers are essential to growing the food we eat, but too much nitrogen in the soil in the form of nitrates can get to the groundwater, which is the source of much of our drinking water. Too much nitrate in our water supply can be harmful to health. With this information, you are as close to the audience as the water they drink. Most intelligent adults will understand what you are saying whether or not they have sat through chemistry and microbiology classes. For kindergartners, you might need to explain even further: The microorganisms may become tiny bugs that we cannot even see. Whatever adjustment you have to make in your terminology, there is no reason to suppose that you cannot communicate with a group of people simply because you are more educated on a narrow topic than they are. Some of your family or your acquaintances fit into whatever audience you must address. Picture those persons and think about how you would tell them what you have to say.

19.5 AVENUES

Identifying the audience and empathizing with them are keys to success with any communication, but how do you acquire such an audience of nonscientists? For the science practitioner, audiences usually come to you. For the research scientist, opportunities will arise. When offered an opportunity to communicate with an audience, accept it. Do not always wait to be asked; there are avenues you can open yourself. You could join civic groups that would be pleased to have you provide expertise on public problems such as safe water supplies or waste disposal. You may belong to an interest group such as amateur bird watchers who would like to learn more about birds, ecology, or other areas that you know better than they. Science writers may ask you for an interview or attend a conference to hear what you have to say about your new discovery. Be prepared with accessible information. With technology and the Internet, the opportunities abound. Science networks, your own website, social networks, your blog, online newsletters—there is little excuse for not knowing where to find an audience.

You may work for a company or agency as a representative, a technician, a consultant, a manager, or a research specialist. That company or agency could provide avenues for communication. Your efforts may be to inform nonscientists within as well as outside your company. Your employer may encourage you to visit civic clubs or schools or write for the popular press. Cooperate with scientists in the Agricultural Research Service and the Cooperative Extension Service to transfer information about what is going on in your scientific research to agricultural producers, land owners, home owners, and industries. Even if you do not work for someone who has science communication as a part of the job description, you can find ways to reach the lay audience. Public school classes and clubs, civic clubs, and garden clubs are often pleased

to have scientists speak about their work. Get acquainted with your children's science teachers and let them know that you are willing to contribute time to their classes. For them or for others, you can make demonstrations or speeches or produce copy for fact sheets, leaflets, technical bulletins, newsletters, policy statements, employee or public pamphlets or brochures, exhibits or posters, and other creative outlets.

The opportunities come in numerous other media. Scientists are invited to participate in interviews or other programs on radio, television, or the Internet. Live interviews are scary at first, but good preparation can alleviate fear. Suggestions by Meredith (2010) and Gastel (1983) can help. Rather than the live interview, you might be more comfortable with other avenues for communication. You might produce your own videotape that can be edited for a given audience such as high school students, first-graders, or the public. You can be invited to give a presentation or a demonstration to a group. Children use computer networks such as Wikipedia to acquire information that we once obtained from the encyclopedia. You could contribute to a store of information on such a network.

The popular press contains a variety of avenues. Without being a science writer, the research scientist as well as the science practitioner can write for a newspaper or popular magazine. Some magazines are dedicated to science writing; others have regular science features. You can submit a feature article or contribute a regular column. You can maintain your research, teaching, or service positions as a scientist and still use the popular press and other media for communication with nonscientists. Both in speaking and in writing, serious science communicators who employ some form of the media to reach the public play a vital role in alleviating some of the misconceptions about science.

19.6 SUBJECT

The subject you select or are asked to write or speak about will depend on the audience and your own area of interest. The garden club may want to hear how to control tomato blight; the civic club may care more about how to effectively dispose of waste that humans and animals create. Farmers may want to know what to do about the soil after a severe flood. Cancer survivors may want to hear how they can best live and continue to avoid recurrence of active malignancy. The specific subject the nonscientists prefer depends on who they are, the work they do, and their special interests. As a scientist, it is in your best interest to provide information that will help nonscientists understand, trust, and appreciate science. They have a right to know what chemicals are in their food or why a hormone can make them feel better and even change their attitudes. They also have a right to know whether genetically altered species might destroy Mother Nature's own creations, why we should bother to protect a blind lizard or a night bird, whether genetically modified plants can destroy native plants, whether nuclear energy is as safe as coal-powered electricity, what side

effect a drug may produce, and hundreds of other questions that affect their daily lives, their jobs, and their government. Help them to know the real risks and any safety precautions needed as well as the benefits.

The subject you select should be timely, important, and based on the interests of the audience. Clearly identify your objective or purpose in communicating your subject. You may tell a group what they can do to control Japanese beetles or help them understand how to guard against a communicable disease that has become prevalent. You could encourage them to read and follow pesticide labels before scattering herbicide in the yard or insecticide in the house. Just like you, they are interested in safety, current happenings, unusual events or discoveries, and new developments in science and technology.

How you treat the subject can be as important as the subject itself. Be cautious with disclosures about new discoveries. It is better to tell the audience you do not know than to lead them through your own enthusiasm to making unsubstantiated presumptions based on what is still experimental. When you do not wish to commit yourself to a possible outcome of a scientific discovery, you can refer the audience to original sources of information and let them draw their own conclusions, just as you do. If those sources are too technical or scientific for them, explain that no one yet knows what the conclusion to the research will be or what applications can be made. Remain positive and congenial if they question your credibility. Do not assume that the audience is unintelligent or has a bad attitude. Principles for good communication require that you respect your audience and react well to criticism even from people who know far less than you do about your subject. By reacting in a calm, rational manner, you can move them toward what you believe is true. It can help to have someone review what you will say or write for a given audience and then make revisions before you deliver the information.

19.7 TECHNIQUES

With a clear purpose, subject, and audience in mind, your task is to move the audience from their current base of knowledge to learning something new. You have to start with what the audience knows already, whether they are high school science students or preschoolers. You need to use more extensive verbal or visual illustrations with the nonscience audience than with your peers in science. Slides, demonstrations, and other displays can help them understand your points more quickly than words alone. Do not hesitate to use scientific data to support what you say or write. Just be sure to present those data in a form that your audience will understand and one that is credible and accurate. To say that a chemical additive in a food is at a mere 0.006 parts per million may mean little to grocery shoppers who conclude that it is bad because it is still toxic and it is in that food. Tell them that it would take a dose of 800 aspirin taken every day for a week to be as toxic as that amount of chemical additive in one bite of food and without it spoilage of the food would be more dangerous to their health. Use

definitions, comparisons, and visual imagery. Use analogies and compare your ideas and conclusions with something familiar to the audience.

Writing or speaking about science should follow the principles of simplicity as outlined by such authors as Zinsser (1998). Be conversational and direct, and repeat your main points for emphasis. Use first and/or second person and the active voice. Watch your tone as well as your vocabulary. Watch out for any note of prejudice or condescension in your diction or tone, even to very young children. It is easy to inadvertently say something that is offensive to an individual or group in your audience. The nurse who condescendingly asks the patient, "And how are we feeling today?" may very well be told how "we are feeling." Avoid complexity and incomplete explanations. Be sure you carry the audience forward with transitions that they understand. These transitions sometimes require more lengthy explanation of what connects two points than would be required with a scientific audience. Narrow your subject to one that can be explained with terminology the audience will understand in the speaking time or writing space you have available.

In addition to conveying the unfamiliar in familiar terms with accuracy, completeness, and simplicity, consider the interests of the audience. What they care about knowing is as important as what you think they should know. They may not care what a DNA molecule looks like or how an *Agrobacterium tumefaciens* can serve as a vector to transfer DNA from one species to another, but they want to know how you can use knowledge of DNA to change characteristics of a tomato or provide evidence in a rape trial. Join them in their world; do not expect them to come to yours immediately. As a good communicator, you can guide them to at least one view of your world if you begin with their own interests and knowledge.

Several sources in addition to Zinsser (1998) can be helpful for exploring the principles of good communication. Blum et al. (2006), Meredith (2010), and Gastel (1983) provide information on media and techniques. But you also may need to return to basic instruction in a text such as that of Burnett (1994) for writing or Smith (1991) and Anholt (2006) for speaking. Read some of the popular science magazines or newsletters in your discipline; you can find many of them on the library shelves next to your professional journals. Read and listen to Carl Sagan, Stephen J. Gould, or other well-known science communicators.

You can have an interesting career in science writing, but you can have a career as another sort of science practitioner or a research scientist and still help to inform the nonscientist about science in an entertaining, educational way. Speaking engagements, writing features, use of the Internet, broadcast journalism, and other avenues can allow you to present written, oral, and visual information to audiences. Whatever form you use, what is important is that you are informing and educating nonscientists about science. Find out where the people in your neighborhood are getting information about science. Then make a commitment to communicate science outside the scientific community.

You do not have to be a Jacques Cousteau or Stephen J. Gould. As a science communicator or a scientific communicator, you cannot provide all the answers to all the public. However, as Richard S. Nicholson says, “Rather than regard such activities as irrelevant distractions, we must realize that informing the public is a vital aspect of our jobs.” If each scientist would contribute a bit of his or her knowledge to nonscientists, scientific illiteracy would not be such a problem. In fact, it could well be that we would all take better care of that world of physical matter that is the subject and breeding ground for science itself.

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Chapter 20

To the International Student

We can work together, men and women, to develop the world.

—Maria Mashingo

Although I have tried to avoid idioms that are too colloquial in this book, for authors or speakers whose first language is not American English, I am sure that some of the things I have said previously are confusing. The lack of clear communication between us is the result of my language adhering all too closely to my culture and education, and your understanding is based on your culture and education. Your English and my English can both be high quality and still be flavored with enough of our cultural background that it is sometimes confusing to understand each other. In this final chapter, I discuss some of those cultural issues that influence our writing, speaking, body language, and even our opinions on what should be communicated and how to communicate effectively. First, I think we have to look at some cultural differences that influence our beliefs, behavior, and lifestyles. All these issues affect the way we write and talk. Then, let us look at the expected conventions for speaking and writing in American English, including such issues as body language and plagiarism that differ among many cultures.

The opinions I express here may or may not be entirely fitting for your situation. You may have studied English since preschool or you may have just begun to learn English in college. You may have traveled a great deal in the United States and already have a clear concept of the elements in our culture. In addition, I am no expert in cultural differences. What I express here is based on my own observations, the literature I have read, and the intensive and extensive discussions I have had with international students at my university. For the following discussion, I refer to the persons from other nations as internationals and those from the United States as Americans. Both these terms are too general for the diversity of peoples included, but for a single chapter on this complex subject, generalizations are necessary.

20.1 BECOMING ADJUSTED TO U.S. CULTURES

The world is too large and complex for any individual to see it from all directions, in every light, and with total comprehension of the physical, nonphysical,

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and metaphysical contents of it. Within the natural physical world, as Hall (1983) suggests, we create much of our own environment by building beliefs and physical structures to accommodate a way of life. In doing so, we develop cultures of people whose speaking and writing are influenced by the physical content of that environment and the values, beliefs, customs, and activities put into it. All these things contribute to a semantic environment in which a language evolves. Where cultures are similar and give us similar data to process for communication, we understand each other. Where they differ, we are often frustrated with misunderstanding.

Fortunately, for scientific communication, a prominent part of the environment is the physical phenomena and common techniques for defining empirical behaviors in that environment. These common elements of science make it relatively easy for persons from different cultures to communicate about science. However, for students coming to the United States from other cultures, it is impossible to separate communication related to your entire experience in this different culture from that which focuses on scientific papers and presentations. Consequently, an understanding of the environment in the U.S. college community and some of the language differences as influenced by our cultures may contribute to your success with scientific papers and presentations for audiences in this country.

What are Americans like? When you come to the United States for the first time, keep your mind open about what you think of the behavior of people here and be flexible in your opinions. Most students and professors in the college communities where you will be living are relatively open-minded and unbiased. As elsewhere in the world, we have our share of narrow-minded people. We also have our individual personalities; one person may smile easily, whereas another may almost always have a worried look or a frown on the face. Your culture is as unfamiliar to most of us as ours is to you. While you are wondering what we are thinking about you, we may be wondering what you are thinking about us. This lack of familiarity may create a distance between us at first. One student told me about going to classes and to meetings for the first few times in the United States and feeling that others seemed to avoid sitting beside her. In a few instances, that behavior could have resulted from prejudice, but it may well be that the U.S. students were uncomfortable with the unfamiliar or saw friends in the room with whom they wanted to sit. Very soon, this student made her own efforts to talk with others, met many who did not avoid her, and felt comfortable in dialogue with Americans.

Yes, we do have people in the United States who hold ethnic, racial, religious, and social prejudices. I suspect you have such people in your country, too. However, I believe that in the university environment, the number of prejudiced minds is relatively few. You may encounter instances of intolerance, but please do not label all of us or of any particular group as narrow-minded and prejudiced. I think you will find most of us like diversity among people and

enjoy having someone with a different cultural background among us. We want to learn from you, and perhaps you will learn from us.

Keep in mind also that the U.S. student is probably more ignorant of your country than you are of the United States. Unfortunately, in this country we do not teach most of our students much about other cultures, other societies, and other countries. Most of them have never lived in or even traveled through another country. Their opinions may be generalizations formed from movies or news reports that do not depict your country as it really is. Be patient with us. When you have an opportunity, tell us about the people, the customs, and the cultural differences in your country so we can learn from you and adapt to you as you are adapting to us. As we share such information, we communicate better. At the same time, any preconceived ideas you have about people in the United States may not be entirely true. Be open-minded to whatever you encounter. We are a mix of beliefs, cultural backgrounds, and social and economic conditions. Movies you may have seen, news reports you have heard, or music you have listened to will not tell you what the United States is like. We are not all lovers of rock or country music. We do not all have good cars and spacious houses, and not everyone has a good education or a good job. And we do not all speak English with the same accents and fluency.

You may fear that you will have trouble understanding our English or making us understand yours. The fact is, throughout this country, we sometimes have trouble understanding each other's English. The English of the African American from Mississippi or the French Cajun from Louisiana and that of the Irish New Englander or the Hispanic from Arkansas may well be as different from each other as yours is from theirs. Do not worry; you will adjust to the accents in the area of the United States where you study. Fortunately, if you are reading this book, you are probably coming or have come to the United States to study and work in science. Science is science wherever you go, and culture and accent affect it less than these might affect communication in everyday life. The vocabulary and the content for discussing science will be similar to what you know, and English accents will not interfere very much. However, to be successful during your stay here, you will have to become accustomed to the cultural and linguistic issues beyond the laboratory or classroom. Especially at first, we may ask you to repeat or rephrase something you say; and do not hesitate to ask us to repeat. But as our ears become accustomed to your sounds and yours to our sounds, we will understand each other quite well.

Every individual is different. Communication is closely associated with the personality of the individual, but that personality is often steeped in unique cultural backgrounds that we may not even be conscious of. Every individual must come to terms with his or her own differences.

If you received your education or grew up in another country and are currently in the United States to attend graduate school, you may find that adapting to the new physical environment is frustrating. Students from some countries

are sometimes amazed at how large the United States is. They may know other students or relatives from their home countries who currently live in the United States, but they find, for example, that from a graduate school in Florida, visiting someone in Oregon may involve traveling almost as much distance as traveling back to their home country of Sri Lanka or Bolivia. Transportation can be inconvenient. Many international students do not have cars of their own, and public transportation systems are not always convenient or may even be nonexistent in smaller cities or towns. As soon as you arrive or before you arrive in this country, try to study the particular place where you will be located. In addition to transportation, foreign students in the United States may be frustrated by the living conditions, the climate, and access to social and religious activities in which they want to be involved. Depending on the area of the United States you are in, the climate may be hotter or colder than that in your country, and it may be difficult to purchase the kind of food you are accustomed to eating.

Talk with other international students who have lived here for a while; especially the ones from your own culture can advise you on how to adjust. With patience, you will survive the environmental frustrations, and temporarily at least, you must adjust to the culture and the language in order to be successful. That is not to say that you have to *adopt* the culture, just *adapt* to it for the time you are here. The United States in general is a relatively new culture made up of numerous influences from various places in the world, and we do not always agree with or understand each other very well. But because of our diversity, most of us try to tolerate and understand differences and do not reject people because of cultural differences or beliefs. Most of us welcome new ideas. You are individually different; so am I. When you meet those individuals or groups who have ethnic, religious, racial, or socioeconomic differences, know that there are variations, and the following generalizations do not entirely describe you or other individuals you meet.

20.2 GENERAL CULTURAL DIFFERENCES

20.2.1 Attitudes Toward the Self

In some cultures, the individual views himself or herself as a member of a group, a family, a neighborhood, or another social group and is more dedicated to the preservation, well-being, and harmony in that group than to his or her own self-interests. In the United States, some people also hold this view, but the individual is often the focus, and allegiance to a group does not take precedence over self-interests. This attitude can be interpreted as selfish and arrogant or as cold and too assertive. Most U.S. citizens view it as independence and freedom of choice and respect for the worth of the individual. The American may see some internationals as too pliable and not individually assertive enough. It should not be too difficult for each of us to maintain our own perspective and to respect that of the other.

20.2.2 Direct and Indirect Communication

Another difference that Hall (1983) and other linguists and anthropologists observe is that some cultures are "high context" cultures and some are "low context." As I understand this concept, in low-context cultures such as the United States, Denmark, or Germany, the communicator is very direct and does not depend so much on the obvious context of the environment or a situation to express an idea. The direct words and body language express what he or she observes, even if the listener is observing the same thing already. In the high-context cultures such as are often found in the Far East or Latin America, the communicator does not feel the need to express what is already obvious in the context of the situation but provides a key expression that allows the listener to make an interpretation of meaning beyond the obvious. One student from Latin America described the attitude of the Danish as rude in that they, in effect, told her that if she did not like their country, she could just leave. She would never have voiced such a suggestion to anyone; that option would be obvious in the context of the situation, and it would be offensive to voice it.

These attitudes are often described as direct and indirect communication. The behavior and attitudes of the American may be seen as rude or uncaring by the international but considered reasonable by the American. Those of the international may be interpreted as weak or insecure by the American but simply adhering to a principle of harmony for the international. Along with direct communication, the American is often uncomfortable with silence and will fill a silence with words even if they are repetitious, obvious, or ineffective. The indirect version of communication welcomes silences as time to think and interpret what is being said and not said. Although it is not likely to happen, perhaps we could all modify our behaviors by mixing the direct and indirect appropriately.

20.2.3 Power Distance

As a complement to allegiance to a group or an individual and to direct and indirect attitudes is the concept of power distance. In groups, there are various positions that individuals hold, such as the parent or eldest son in a family, the boss or coworker on the job, and the teacher or student in the classroom. Behavior and communication depend on how respect is expressed for the various positions in the group. For example, in some cultures, children are expected to remain silent in the presence of most adults or students are expected not to express opinions contrary to the opinion of the teacher. These practices are conducive to group harmony. In the United States, we generally encourage children or students to voice their own ideas both at home and in the classroom. At school, this concept lends itself to the use of different teaching techniques, and the international student accustomed to being silent in class may find it difficult to speak out when expected to join a class discussion in the United States. The international may view children or students in the United States as rude and

disrespectful, and the American may view the international student as being too timid and reticent. Even professors may misinterpret silence as a lack of knowledge when, in fact, it may indicate clear understanding. Open discussions about this difference are probably the best way to reach an understanding with each other. In the classroom and with study assignments, the international student needs to adapt to the techniques used. Talk with the instructor of any class about what you do not understand.

20.2.4 Time

A most interesting subject for me is the cultural differences in our concepts of time. Our ideas of the priority time has in our lives, the importance or lack of importance of punctuality, and our management of time or schedules are often different for different cultures. Treatment of time may stem from whether we give more priority to strict scheduling of events or to choosing to act when the time is most convenient or appropriate. In the United States and in other low-context countries, adhering to schedules is important. Being late or early or taking more time than is scheduled for an event is generally offensive. The Latin American student who studied in Denmark was invited to have coffee one evening with a native Danish student. She finished her work that evening and went to his apartment to enjoy coffee at 6 o'clock. He was extremely offended; coffee time was apparently a somewhat ceremonial event, and evening coffee time was 8 o'clock. Although she had not been familiar with this custom, he sent her away and asked her to return at 8 o'clock. She did so out of deference to his culture and to her own sense of harmony, but in her country it would have been rude and insulting to have sent a guest away because of a customary time schedule the guest did not understand. In this instance, it may have been only the individual who appeared rude to the guest, but she went away with the impression than Danes are rude. If someone offends you while you are in the United States, do not assume we all have the same attitude. Most Americans are more flexible than that Dane, but most have great respect for schedules, and professors may not understand a cultural lack of punctuality in turning in assignments or your coming early or late to a class or an appointment.

Which is best—the greater or lesser power distance, the direct or the indirect communication, the group or the individual focus, strict or loose adherence to time schedules? Our cultures and our personalities dictate the answers for us as individuals, and it is certainly not the purpose of this chapter to debate the advantages and disadvantages of the different behaviors and communication styles. But understanding that these differences exist may explain to all of us why and how we do some things or communicate differently. Our purpose here is to determine how these cultural differences affect scientific writing and speaking and to make all of us more comfortable with any audience. Your goal as an international has to be to make whatever adjustments are needed to be successful in your work here without ever losing your own cultural identity.

These general cultural differences can clearly affect your speaking and writing in American English.

20.3 SCIENTIFIC WRITING IN AMERICAN ENGLISH

If you are an international from a culture in which indirect language is preferred, you may find that your reading audience—whether professors, other students, or journal readers—may think your literary style is too diffuse or rambling. Students tell me, and Fox (1994) says her students tell her, that professors often instruct international students to "get to the point" and be more concise and direct with support for a point. I certainly will not argue about whether a forceful, direct approach is superior to other forms of communication, but it is the form used for audiences in the United States, and for communicating with those audiences you will need to adapt to this style or technique.

This adjustment in organization and development of a topic may require that you add a pattern of thinking to your education. My contention is that the truly educated individual is the person who can and does communicate well with any audience with whom he or she comes in contact. Patterns in thinking constitute the base for our patterns of expression. Maintain your own patterns in the process; they will be important when you communicate with the audiences in your culture. However, try to develop a thinking pattern that makes you successful also with communication in English. Developing new ways of thinking and communicating is difficult. Montgomery (2003) has suggestions for adapting by using models of English papers for developing skills in reading, speaking, and writing. I would add listening to those skills. For writing a paper, it may be helpful to study Montgomery's ideas, or read Chapter 3 of this book and study the example in Appendices 2 and 3, but let me expound upon some of these ideas more specifically here.

Because some of the difference in direct and indirect communication is in the organization of thoughts, probably the best way to learn a new communication technique is to begin with an outline or a listing of points in the order you will develop them. Know that for scientific writing in American English, the main point comes near the first, and then you can give information about and support for that point as you develop the paper. We think of this technique as logical and reasonable, but it may be no more valid than a method that considers various background points of support and leads finally to a main point or conclusion. Again, our purpose is not to determine superiority of one method over another but, rather, to make it easier for you to successfully communicate with the American audience. To begin thinking in an order that puts the main point first, I suggest that you follow a basic pattern or outline. I recommend this same process for American students who have trouble with organization and development of material. The suggested length of each part in the following discussion is based on a typical journal article. If you are writing a book or a thesis, each part may be longer; if you are writing an abstract or a short report, each part may

be shorter. In addition to the following information, look also at Appendix 3 for an example of an overly simple outline and paper that follow this pattern.

20.3.1 Introduction

The introduction for a journal article will typically do the following: (1) It will almost immediately call attention to and define or clarify your specific topic for the audience, (2) it will provide any information or previous literature necessary for understanding the topic and justifying why you are working with it, and (3) it will clearly define your point or objective relative to the subject. In an abstract, these things would be done briefly, with a sentence of rationale and definition that takes care of the first two things and then a specific statement of objectives. In the journal manuscript, in no more than two double-spaced pages you may define and justify the subject, provide background information on the scientific reasoning involved and make reference to the literature showing what other researchers have found, and then suggest a basic hypothesis and specific objectives on which your research and this subsequent report are based. If you find direct communication is foreign to your way of thinking, this introduction is the part in which you may ramble or not get to the point unless you curb your desire to discuss too much background or too many ways of approaching your objectives. Just describe your particular topic, give clear and direct rationale for studying it, state your hypothesis and objectives, and move on to the next section.

20.3.2 Body of Paper

The main body of most scientific reports is composed of materials and methods used in the research, results acquired, and a brief discussion of the meaning of those results relative to what your initial purpose or hypothesis was and relative to what others have found about the topic previously. Day and Gastel (2006) can be helpful with their descriptions of these sections. The materials and methods section, which may also be called by such terms as experimental procedures, tells other researchers anything they would need to know to perform the research just as you have. Thus, you must describe all the materials needed and perhaps where you got them and the procedures you used with those materials to pursue the objectives. Include information on both scientific and statistical analyses. An easy way to organize this section is to arrange it in the step-by-step procedure you used or by objectives and describe the techniques you used to test each one.

The results should be a clear presentation of representative data from your study, probably much of it in the form of tables and figures. However, some results can and should be stated more simply in just the text, and the text should directly point to the significant findings depicted in the tables and figures. Start with a statement of the main results of your experimentation, and then support

that point with the data. The discussion may be interwoven with results, or it may be a separate section. As with the introduction, take care not to ramble away from the main point in the discussion; just associate your interpretation of the meaning and significance of your results with scientific principles and reference to what others have found.

20.3.3 Conclusion

A conclusion to your paper should briefly reiterate specific points about what your objective sought to accomplish compared with what was actually accomplished without detailed repetition of results and discussion. It may then show how the results from your work can be used in future research or in practical application, but do not go too far with this speculation. Finally, you will attach a list of references and any acknowledgment that is needed.

This organization and content development of a research paper to be submitted for journal publication were described previously in this book and in more detail in Day and Gastel (2006), and they are illustrated in Appendix 3. Similar direct patterns of organization and development can be designed for a short essay as in Appendix 2 or for the thesis and other research reports. The proposal will follow this pattern except for omitting the results and discussion or including them only as preliminary findings. See the chapters in this book on theses and proposals, and study the proposal in Appendix 5. For all kinds of writing, reading some of the experiences of international students who have worked with Fox (1994) may also be helpful if you are frustrated with adjusting your ways of thinking and writing for an American audience.

20.3.4 Plagiarism

In both speaking and writing, an important issue in the United States is the concept of plagiarism. With the teaching techniques and practices in some countries, I have been told that it is a gesture of admiration and respect to another author to use his or her concepts and words in your own speech or paper. And in your culture you may often do so without noting specifically where your words and those of the original author are the same. In the United States, we consider the tangible expressions of an author to be his or her own intellectual property and must ask permission for or acknowledge use of it. This intellectual property may exist as the words describing a concept or other media such as data in tables and figures, choreographic or musical scores, or other tangible forms of expression. The use of intellectual property by others can be considered theft and is unethical and even illegal if it is not clearly documented or permission is not obtained.

Of course we use information from others, and if it is a few short lines, it can be paraphrased with different words or put in quotation marks if the same words are used, and then the source is clearly cited to distinguish which words

and ideas are yours and which are from the other. If longer passages of information are used, one should determine who owns the copyright on the words and obtain copyright permission before using them. Sometimes permission is freely granted and sometimes an author will charge a fee for using his or her words. For example, in Appendix 7, Dr. Vander Stoep gave me her permission with no charge or restriction, but for Appendix 12, I paid the publisher who owned the copyright for Imhof's work. In both instances, I have retained the letters I wrote and the written permission in their replies as evidence I have not stolen intellectual property.

If you are accustomed to the practice of using other sources freely without clear documentation or permission, you need to be careful that you adjust to the system of documentation in the United States. All of us use information from others, but we document any that comes from other sources and even use quotation marks if the information is verbatim. We also find unacceptable the use of too much information from a single source without copyright permission even when it is documented or of using your own words that you have written for an earlier paper without referencing that paper. This may seem a simple matter to you, but it is very serious with work in the United States, and professors my fail your work if they detect plagiarism. For your own sake, then, try hard to understand the concept and adhere to it while you are working here. I provided some information on plagiarism in Chapter 12. You can also explore the Internet for definitions and examples of plagiarism.

20.4 ORAL PRESENTATIONS

Even more than in writing, cultural background and personality influence the spoken word, and international students appear to me to worry more about speaking English than writing it. If your knowledge of English is basically good—and for most international students, I find that it is—then just give yourself a few weeks in this country and your ears will be attuned to what you hear and you can be speaking the language quite well. Some of my students worry about their accents. I tell them pronunciation and enunciation are important, but they should keep their accents and be proud of them. Accent is a part of pronunciation, but the sounds include tone, inflection, and variations in the rhythm and pitch of the voice, as well as your distinctive manner of expression as it depends on the phonetic qualities of your first language. If you travel in the United States, you will find that we also have variations of English accents in different areas of the country. The Bostonian may have problems understanding the person from Georgia or Louisiana. Your accent is likely no more distinct than those. If you are careful with basic pronunciation and speak distinctly and slowly enough, you will likely be understood.

Articulate the basic English sounds as clearly as you can. Some of those sounds may not be present in your language, or one sound is almost indistinguishable from another for you. One young man from Saudi Arabia told me

that the sounds of *b* and *p* are indistinguishable in his language. At a parking lot in the United States, he asked a policeman if he could "bark here," and the policeman smiled and said, "Of course, you can bark anywhere you like." Unfortunately, when the young man returned to his parked car, he had a ticket. He quickly learned to make a distinction in the sounds of *b* and *p*. Listening, reading aloud, recording and listening to yourself, and talking in English will develop your ability to speak English well. Speak English most of the time while you are in the United States.

These listening and speaking exercises will also help you to develop vocabulary and sentence structure. The order of words, the use of articles and plurals or other word forms, and the construction of sentences may be different in English than in your first language. You learn these things as you study English, but becoming fluent is a matter of using the knowledge you have. It is rather like swimming: You can be told how it is done, and you can repeat that information, but you have to get into the water and actually perform the action in order to successfully swim. To really master the art of swimming, you have to practice the right strokes and the right breathing technique and learn to relax in the water. The same is true with speaking a language: Practice the right pronunciation and the right order of words, and you will master the language. In either situation, if you do not practice or repeatedly practice the wrong action, weaknesses will become difficult to overcome. Most important, do not resort to spending most of your time with others from your own culture and speaking your own language with them. Even if you speak English with them, you are not giving your ears a fair measure of American English. Associate with your American colleagues. Some international students even encourage their American friends to point out their weaknesses in pronunciation and vocabulary. In turn, they sometimes offer to teach the Americans some of their own language. Such an exchange is mutually beneficial and semantically healthy.

Slang and American English idioms can be confusing. You will also get more of these than you need by listening and talking with Americans. However, it will be just as well if you avoid much of the slang and the meaningless expressions, especially in speech making. Most of the time, you should avoid such insertions as "OK," "Umm," "like," "stuff like that," "you know," and "yeah." Crude, offensive slang should especially be omitted from your speech. Just because some Americans use those terms does not mean they are effective. Many of us are sloppy with our use of language. Learn the right stroke in swimming and learn the right term in language. Do not use an expression until you know what it means.

As in writing, some Americans are often very direct with their spoken words and may appear rude to you without meaning to be. For us, directness is not rude but simply the pattern of making the point clear to begin with and then discussing issues involved. Depending on your culture, you may put background and discussion first and then end on your main point as you may do with writing. In making speeches or presentations, it is important that you adapt

to the American pattern so that the audience will follow your talk better. As with writing, this adaptation may involve the difficult process of altering your pattern of thinking.

Speed, pace, and volume are all important to good speaking and audience comprehension. Speed and pace are different but related qualities. Obviously, if you talk rapidly in any language, it will be more taxing to the listener to keep up with what you are saying. Some of you may have developed rapid speech because of the influence of your own language. Sounds in some languages are formed in the front part of the mouth and can be emitted far more quickly than those sounds that originate deep in the throat. For example, many sounds in Spanish originate in the front of the mouth and are quickly emitted; many in English come from a Germanic language in which the guttural sound originates deep in the throat and the sound emerges more slowly. I find many of the students whose first language is Spanish speak English rapidly. However, if this speed is modified with the pacing of words and phrases, the language is easier to comprehend. Pace involves pauses—small pauses after phrases and clauses and longer ones after end punctuation. A phrase or sentence may be spoken rather rapidly if it is followed by a pause. These pauses allow the listener to catch up and keep up with sounds and meanings. They are important for speakers in any language. Just do not pause so long that the silence is awkward. Both American and international speakers should be conscious of speaking at an appropriately slow speed and pacing their delivery well.

The issue of volume can be a problem for speakers of any language. Seldom is the problem one of talking too loudly, although a few speakers do so and appear too aggressive to an audience. For many international students, the opposite is true. Power distance or harmony issues relative to age, prestige, position, or gender may have caused you to develop a soft low tone and volume to your voice. The tone is usually pleasant, but the volume must be great enough that it can be heard. In a large room, it is essential that you project your voice so that everyone in the audience can hear you. If you have a low voice, use a microphone if it is available. If not, you must make every effort to increase the volume and projection of your voice to accommodate the situation. You may as well not say anything if what you say is not heard. All these remarks are true for the American English speaker as well as international speakers. Nervousness in front of the audience, a feeling of insecurity or inadequacy with the language, or timidity and cultural issues with power distance can make you talk too fast, fail to pause, or speak too softly. Be conscious of any of these problems you may have and remedy them.

International students can often adapt quite easily to the rather formal speaking situations, such as making a presentation before an audience. The semantic environment of small group meetings can be somewhat different. Here, the diversity of individual cultures and personalities is multiplied. Cragan et al. (2009) present information on cultural diversity that might be helpful in a small group situation, and Beebe and Masterson (2011) discuss conflict in

small groups relative to cultural differences. As with developing your communication skills in other semantic environments, the best way is to observe and participate in the group. You may want to read Chapter 18 for other ideas on how to best participate in small groups.

International students have told me that, especially in their first days or weeks in the United States, they are frustrated and uncomfortable with casual conversation, especially with such things as greetings or use of names and titles. We have so many ways of greeting each other, from "hi" or "hello" to "good morning" or "good afternoon" to "how are you?" or even very casually "what's happening?" or "hey, what's new?" Any of these are appropriate at the right times; listen for clues to when Americans use one or the other greeting, and until you become comfortable with them, you will be safe to simply say "hello" or "good morning (afternoon)." At first, you may also feel uncomfortable with the way you address others, especially those who have titles. And names are treated differently in different cultures. Some international students are afraid they may not address their teachers appropriately. Again, in the United States, we have no single right way to address them. Let's look at an example of someone named Mary Jones, who is a professor with a doctoral degree. Some professors even prefer that their students, especially graduate students, call them by their first name—for example, Mary. Many prefer to be called Dr. plus their family name, as in Dr. Jones. At some schools, it is still fashionable to refer to her as Professor Jones. My suggestion to you is that you call your professors Dr. plus the family name (Dr. Jones) until you determine his or her preference.

20.5 BODY LANGUAGE

In speaking, perhaps body language and what is unspoken are more important than the words spoken. In fact, Hall and Hall (1990) say that 90% of our communication with each other occurs beyond the words we speak. The expressions on our faces, the gestures we make, the way we respond to silences, the clothes or jewelry we wear, our hair style—every element in our interpersonal contact says something to the audience. You will learn most differences in body language by observation the same as you learn other meanings in language. Some body language is fairly universal, but even a smile or frown or a nod of the head may be interpreted in different ways. A smile, for instance, certainly has a similar meaning worldwide, but one student from Serbia told me that Americans smile too much. She resented a speaker who "smiled too much" as he presented serious scientific data. As with other qualities in language, some of the interpretation rests with the personality, but the culture also influences meanings.

Some physical gestures are more distinct for different cultures than the smile. In general, Americans and internationals accept differences in most of these behaviors and can easily coordinate meaning without misunderstanding. For

instance, if your culture prefers that your clothes be different from what we view as the usual American attire, most of us find it interesting but not objectionable, and we will see beyond that difference to interpret your communication appropriately. The same is true of a gesture such as a bow that may be common in your greeting of a professor. English and American people used to use the bow especially relative to power distance, but as we have shortened the power distance in American society throughout the years, we have essentially lost the art of bowing. Still, it is generally quite acceptable to have someone from a different culture bow when he or she is greeting us. When he first arrived here, a young man from Korea bowed his body from the waist when he spoke to me in the hallway; within a few months, he had modified that by simply giving a bowlike nod of his head. I was certainly not offended by either gesture. You may become acclimated to America more fully and bow less after you have been here for a while, but such a gesture is in no way objectionable.

Other body language in greeting or leaving someone can be quite different for different cultures. In the United States, we generally reserve the hug for a rather personal display of affection or a recognition of another person's especially good or bad fortune. For instance, if someone just won an important award or had just experienced a death in the family, we might give him or her a hug even if ordinarily we would not do so. It seems to be a way to say "Congratulations" or "I'm sorry for your misfortune." But hugs, like the kiss on the cheek, in greetings and leave taking are typically reserved for close friends and family in most groups in the United States. The handshake is our most common expression as we greet and sometimes as we leave someone, but it is not always used. Sometimes a touch or pat on the shoulder is an expression used. Whatever your own culture dictates, do not be offended by our shoulder pat or handshake regardless of the sexes involved. If you find such touching objectionable, explain that to whoever uses the gesture. While you are in the United States, probably the best idea for any of you who feel unsure about these expressions is to use the simple handshake and talk with American friends about their interpretation of body language and tell them how your culture uses different gestures.

Power distance has established precepts for eye contact among individuals in most countries. In the United States, where direct language is preferred and power distance is not great, most people expect direct eye contact between speakers, no matter what position they hold or what age or sex they are. Lack of eye contact often indicates to the American that the speaker is not being truthful or the listener is not listening. Thus, a father may demand of his son, "Look at me when I'm talking to you!" We carry this notion of eye contact into our professional and scientific worlds and expect speakers to make clear eye contact with audience whether the audience is a single individual or a group. Because of this expectation, many international students find communication awkward. Americans also find it awkward to talk with internationals who resist eye contact. If you detect that a professor is frustrated with you because of lack of eye

contact, probably the best thing to do is to explain your background, and the professor will probably understand your ideas of respect. But perhaps try to develop an ability to make that eye contact while you are in the United States. As with other cultural adaptations, do not lose your original cultural concept; you will need it when you return to your country. Our method is not better; it is just different. We are not trying to be rude and disrespectful.

Even with differences, most body language is fairly easy to understand across cultures. If you detect that a nod of the head or a beckoning with the hand do not fit your meaning for those movements, clarify the issue with the speaker and move on. A side-to-side shake of the head means "no" in our culture, whereas it indicates agreement in some others; the same or similar hand gesture may have distinctly different meaning in two cultures. As with writing styles and speaking patterns with words, try to adapt to the U.S. meanings of body language while you are here or avoid the gestures that have different meanings. Adaptation is simply increasing your education, not adopting a new culture for yourself. Be proud of yours, and keep it for communication with others in your own culture. The following are my suggestions for the international becoming accustomed to work or study in the United States. If any of them conflict directly with your beliefs or personality, you may have to modify them to satisfy yourself. The first one is most important.

1. Be flexible in your interpretation of us and in your willingness to adjust to this culture.
2. You need not become Americanized; keep what is important to you, but in communicating with the American audience, just adjust to their techniques.
3. Listen, read, write, and speak English every day as much as you can.
4. Get rid of any preconceived ideas you have had about the United States and the people here, and be patient with our attitudes.
5. Be patient with yourself. You have just come into a new world; you will soon adjust to the food as well as the language.
6. Make friends with Americans; make the first move; start the conversations; ask for interpretations when meanings are not clear.
7. Be true to yourself, your personality, and your culture. Adaptation is not adoption.
8. Get help if you need it. There are likely support services for international students at the university you attend. Ask questions there, but learn from others too. Your faculty advisor is usually eager to answer your questions or talk with you about cultural differences. Your fellow students generally want to help also. Do not be afraid to approach them to ask for help; if the first one does not respond well, try another. Many of us welcome you and want you to feel comfortable in the United States. Let us help.

Most of what we learn about each other's cultures and techniques for communication comes from first-hand experience. The ideas presented here are meant only to stimulate your thinking as you adjust to communication in a

different culture. If you are an international graduate student in the United States, you will be able to adapt to our kinds of academic writing and professional speaking simply by observing and perhaps processing a different pattern of thinking. That processing is not an easy matter, and you may be more successful if you investigate some to the fundamental reasons why your thinking or expressing yourself are different from what you find in the United States. To assist that understanding, it may help to read the writings of people who have studied these issues in-depth. I suggest reading some of Edward T. Hall's books, such as *Beyond Culture* (1977), *Dance of Life* (1983), or Part 1 of *Understanding Cultural Differences* (Hall and Hall, 1990). In that section of the book, he and his coauthor, M. R. Hall, discuss key concepts in cultural differences. Especially relative to differences in writing for U.S. and other cultures, Helen Fox presents interesting views in *Listening to the World* (1994). Some informative chapters in *Faculty and Student Challenges in Facing Cultural and Linguistic Diversity* (Clark and Waltzman, 1993) deal with students from particular cultures relative to their adjustments in studying in U.S. schools. A dissertation by Deborah Westin (2007) at Virginia Commonwealth University contains information on support services offered to international students at universities in the United States, and she presents case studies of six international students whom she interviewed. Montgomery's (2003) suggestions are good for college students. Even before coming to the United States, I recommend that you also read Robert L. Peters (1997) *Getting What You Came For*, especially the part in Chapter 23 that is specifically directed to international students.

Whatever our cultural differences and goals of the human spirit, our academic goals and our human motivations and desires are relatively the same worldwide. Our acceptance of those likenesses along with our sincere attempts not only to tolerate but also to encourage diversity in communication can lead to greater understanding by both domestic and international students who work together in science, engineering, and technology. Open minds delight in diversity, but for clarity in science we must yield to conventions of the society in which we are communicating. While working in the United States, international students can adapt to U.S. conventions without losing sight of their own personalities, communication styles, and cultural values. A mark of an educated individual is an ability to communicate with many different audiences in a variety of circumstances.

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Third edition

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Preface to the First Edition

Whether it is a chemical structure, the anatomy of a rose, or an odyssean siren hidden in the recesses of a DNA code, something stirs the curiosity and lures people into the realm of science. Most scientists are effective, intelligent, logically thinking individuals who are coordinated enough not to destroy the laboratory or the field plans and samples, but many of them become frustrated with communication. The siren did not tell them that many hours of their scientific days would be spent writing reports, preparing for presentations, serving with committees to solve problems, or telling the nonscientist about the value of the science. This book is an attempt to alleviate some of those frustrations with papers and presentations.

Because it is a single, relatively brief volume, I cannot hope to treat every kind of scientific communication in great detail. Other more definitive books concentrate on their respective subjects such as writing skills, journal article publication, writing proposals, group communications, public speaking, and all the other topics to which I have dedicated single chapters. My purpose here is to introduce fledgling scientists to most of the kinds of professional communication that will confront them during graduate studies and as career scientists. My objectives are (1) to answer the basic questions that might be asked about scientific communications and (2) to refer the scientist to more detailed sources of information.

To accomplish these objectives, the first part of the book proposes some practical ideas relative to preparing for, organizing, and producing a rough draft of any scientific paper or presentation. From these general concepts, the book moves to specific written forms that graduate students in science will likely encounter—the literature review, the research proposal, the graduate thesis, the journal article, and the practices and problems that accompany these forms. In scientific writing and speaking, it is important to understand publication styles, abstracts and titles, presenting data, reviewing and revising, and even ethics, copyrights, and patents.

Although a clear distinction between written and oral forms of scientific communication cannot be drawn, I have concentrated in the latter part of the book on slide presentations, communication without words, effective visuals, poster presentations, and oral group communications. I include a chapter on communicating with nonscientists in both writing and speaking.

The appendices and the references are perhaps more important than they are in most books. The appendices provide additional information and

examples on the topics discussed in the text. The references extend the views on communication beyond what I can include in this volume. I can give you an introduction to each topic, but you must go elsewhere for other details. At the end of each chapter are references cited in that chapter. Finally, following the last chapter is an annotated bibliography of select works that I find most valuable. I am grateful for what I have discovered in all these sources and believe reference to them will be valuable to any scientist.

Everyone who begins a career in the sciences would do well to have had courses in technical and scientific writing, public speaking, group communications, graphic design, scientific presentations, journalism, leadership and interpersonal skills, professional ethics, audiovisual principles, rhetoric, and other subjects that develop the practical skills of communications. Because taking all these courses would accrue enough college credits for more than a degree in themselves, it is unreasonable to suppose that scientists will be trained in all these areas. They will have little time for practicing writing and speaking skills beyond the efforts required by their work. Similarly, the reading load for a given specialized area of science does not allow time to read all the books that have been written on the formats and skills used in scientific communication. This single handbook will often answer the questions that a graduate student or scientist would ask about scientific papers and presentations and will provide references that can lead to more comprehensive information.

I owe a debt of gratitude to all the graduate students in the sciences who have asked the questions I attempt to answer here. They have provided the motivation and stimulation that have prompted me to put my lecture notes in a form to provide assistance in communication for any graduate student, scientific neophyte, or even the seasoned scientist who may consult this book. I appreciate all that these students have taught me. A special thank you is in order for Terry Gentry, David Mersky, and Katie Teague who have allowed me to use their work in my examples.

I also appreciate all the colleagues who have encouraged me in my teaching and writing, but especially helpful has been Duane Wolf. Without him I would never have pursued this or many other projects. His contributions to the subject matter and to my morale are immeasurable. Thanks, DCW.

Others have helped with the writing, reviewing, and revising, and I truly appreciate their time and attention. Thanks to Marion Davis, who read the whole thing, scrubbed out much of the wordiness, and complained very little the whole time. Thanks to Jody Davis, who read much of it too and was always there to buffer me from the word processor and to keep me motivated. Special thanks to Nora Ransom who gave helpful suggestions on much of the text. Other reviewers on particular parts include Carole Lane, Sara Gregg, Rick Meyer, Lisa Wood, Lutishoor Salisbury, Bob Brady, Domenic Fuccillo, and Bill DeWeese. Suggestions from all of you have helped tremendously.

For the appendices, Justin Morris provided information for the abstract; Gail Vander Stoep allowed me to use her review of a manuscript; and the

editorial, "Let There Be Stoning," is from Jay Lehr. I appreciate all of these contributions and the permission granted by Marilyn Hoch, Senior Editor of Ground Water, for the use of Lehr's editorial. I appreciate the permission from Walter de Gruyter & Co. for use of the excerpt from pages 69 to 73 of Eduard Imhof's book, *Cartographic Relief Presentations*. Thanks to E. M. Rutledge, M. A. Gross, and K. E. Earlywine as well as D. C. Wolf for the use of a photograph and the text of their poster.

For artistic contributions, I thank Gloria Fry who has provided most of the illustrations, but also Steve Page for the computer drawing on posters. I appreciate the use of Martha Campbell's cartoon, which appeared originally in the *Phi Delta Kappan* (**73**, 130) and the one from A. (Toos) Grossman, which was published in *The Chronicle of Higher Education* on July 1, 1992.

Finally, a special thanks to Aaron Davis for his constant love and support.

MD, 1996

Preface to the Second Edition

The Celtic culture was based upon a complex, interwoven set of beliefs as depicted in the characteristic representation of their tree of life on the cover and in the frontispiece of this book. The Celts were a powerful but somewhat disjunctive civilization bound together by common convictions. For the most part, they have become recognized chiefly for an influential cultural and linguistic legacy that is still quite evident in Great Britain and Western Europe. Their influence on succeeding civilizations, cultures, and languages could have rivaled that of the Greeks and Romans in the Western world with one major exception: They essentially had no written language whereby to preserve and transfer information to those who followed. Instead, they depended almost wholly on oral communications to transmit their knowledge of law, science, history, and culture from generation to generation. Consequently, what we know of the Celts comes to us through the writings of other cultures. Their visual communications were exceptionally strong and remain with us today in the Celtic art and statuary found throughout Europe. Through visual imagery, the Celts preserved some knowledge of their culture and symbols for today's world. Their images reflect the fractals in nature and are now used as symbols communicating a wide range of ideas from love to the continuing cycle of life.

Preservation of the legendary Celtic oral tradition did not fare as well as their art, except when stories were recorded by early Christian scholars. The ultimate flaw in the Celtic culture was in their system of communications. A nonexistent written tradition and over-reliance on oral communications leave us little knowledge of an ancient and once powerful civilization. They have provided a compelling demonstration of the importance of both writing and speaking, especially in science where an immediate or oral presentation of information and a more lasting written form of knowledge are needed to sustain the progress of learning. As Scott Montgomery suggests, "Science exists because scientists are writers and speakers."

The Celtic tree of life, as designed here by Sheri Wheeler Wiltse, can represent a view of life, but also it is a fitting image of the complexity of communication itself with its evolving languages and various roots and branches, visual images, and the myriad of cultural and environmental influences in the semantic ecosystem. In spite of the impossibility of understanding all the components that evolve, grow, interact, and interweave to make up the tree of semantics, our job as communicators of scientific information is to simplify this complexity as much as possible for other scientists as well as nonscientists

whose work and lives are influenced by our messages. The goal of this second edition of *Scientific Papers and Presentations* is to improve upon the earlier attempt to aid graduate students and other scientists in their efforts to understand what influences their scientific papers and speeches and to communicate more clearly both with the written and spoken word and visual imagery.

This edition has been extensively revised, expanded, and updated. Like the first edition, most chapters are relatively independent, and you can go directly to the chapter that deals with the subject you are interested in. However, I suggest that you read the first two or three chapters to get an idea of my own attitudes toward communication. Additions and changes to this edition have again been motivated by the questions and needs of my graduate students in the sciences. Probably the questions that I get most often begin with "Where can I find …" or "Can you show me an example of …". I've tried to answer these with a concentrated attempt to update the literature as thoroughly as possible and to add more appendices to provide ready, recent sources or examples that can be helpful for writing, speaking, and using visual aids. I have added a chapter dedicated to international students studying science in the United States. And I have made a fervent effort throughout to improve my own communication with my readers. I will have been successful, albeit less than perfect, if this edition proves valuable to students of science.

I again acknowledge with sincere gratitude those mentioned in the preface to the first edition for their invaluable contributions to this version as well. From among them, let me accentuate for this edition the support of Jody Davis for her reviews and her computer enhancement of the tree of life drawing. I am certain that without Jody I would have given up or still be working on the computer technology that goes into producing a text today. Also, thanks again to Marion Davis Dunagan, this time especially for her enlightenment about the Celts. I reiterate the contribution of Luti Salisbury in updating the material for literature searches. Additions to the list of contributors are equally important. First and foremost is Sheri Wiltse whose idea of drawing the Celtic tree of life gave me a vehicle for expressing the complexity of communication and whose influence and encouragement have become a striking enrichment to my life. I thank Magnolia Ariza-Nieto, Andrea Wilson, and Vibha Sirvastava for use of their poster. For their suggestions relative to the new chapter on international students, I am indebted to the comments of Carol Ojano, Pengyin Chen, Elizabeth Maeda, Luis Maas, Ali Jifri, Maria Mashingo, Nilesh Dighe, Palika Dias, Christian Bomblat, and Wenjun Pan as well as other international students who have enriched my classes.

And always, I want to recognize that major force in supporting all my efforts, Aaron Davis.

MD, 2004

Preface to the Third Edition

To develop a truly effective ability to write and speak to an audience, one needs a belief in the importance of communication for its contribution to science and the human exchange of information. The Tree of Life on the cover of this book symbolizes the myriad influences on human existence and is analogous to the living foundations upon which every communication effort develops. It is in this evolving and changing culture of communication that the semantic environment of science grows.

In this third edition, we cover a wider range of topics than do most books on scientific writing and presentations, and we do not aim toward one particular discipline in the sciences. We provide the fundamentals of communication along with discussion of associated topics such as ethics and legal issues, communication without words, the challenges faced by the international student, communication with nonscientists, and other concerns that anyone working in science may encounter. Where the confines of this book limit detailed discussion, we recommend the best sources we have found in the literature that offer more information. In other words, this book may be the first source you consult that covers the fundamental information needed in a broad range of areas.

This edition offers updates and revisions to accommodate new developments in publication and presentation of scientific research. Although the book is still aimed primarily at graduate students in the sciences, we have designed it to reach a wider audience of scientists and science practitioners. We maintain our focus on the fundamentals of communicating scientific research and its applications to those audiences. In using this book, we ask that you begin by reading the first two chapters to acquaint yourself with our communication philosophy and issues the subsequent chapters address. Then, depending on whether you are a practicing scientist or a graduate student, you will decide which chapters are important to your immediate situation. As you need information on the individual kinds of scientific communication and tools for that communication, go to the particular chapters that apply. There you will find suggestions that will help you practice good communication techniques in your papers and presentations. Along with references to other resources that may be helpful, where applicable we have cross-referenced additional chapters and appendices in the book that elaborate on important points.

In prefaces to the first and second editions, we list persons who contributed both to those editions and consequently to this edition. We appreciate all of them. For this revision, we extend a special thanks to Lisa Wood for her reviews,

her discussion of content, and her friendship. Thank you to Marilyn McClelland for sharing books and ideas and to Sara Dunagan for her review of Chapter 1. Thanks again to Sheri Wiltse for the Tree of Life on the cover and frontispiece. A special acknowledgment to Gloria Fry, who contributed the unidentified cartoon figures throughout the book, and to Kaitlin Strobbe, Fran Walley, and R. E. Farrell for providing their poster. Finally, a sincere thank you to all the students who, throughout the years, contributed their questions as well as their answers relative to all the struggles we face in communicating well in science.

Martha Davis
Kaaron J. Davis
Marion M. Dunagan

Appendix 1

Weaknesses in Scientific Writing

When we mention weaknesses in scientific writing, I am afraid many people envision misspelled words, too many commas, or sentences that contain other grammatical errors. Those distractions can be serious if they are prevalent in a paper, but they are often the result of larger, more serious issues that the author may have neglected to consider. The most serious problem with most scientific papers is an unwillingness or inability of authors to proofread and review their own work objectively and revise it rigorously. Failure to polish a draft is a weakness in itself and allows other weaknesses to be too prevalent. If you feel uncomfortable with detecting weaknesses in your own paper, check carefully on the following elements in your writing. Then read your paper aloud and slowly; you will likely recognize things in this reading that you overlook in rapid, silent reading.

A1.1 LACK OF PREPARATION

Some people begin to write before they are ready or before they have carefully studied a subject. You must have an audience in mind and have something to say to them. Be confident in your own knowledge and opinions, but to achieve credibility, you must know your subject and believe in what you are saying. You need to support that belief with scientific principles as well as credible information from your own data and other research findings. In other words, prepare by studying and understanding the literature, the science, and your data and by talking with others about the subject.

A1.2 WEAK ORGANIZATION

A research report must be centered around one point of emphasis. That point, often called the research question or hypothesis, constitutes the purpose of the paper and gives birth to the objectives and supporting points. A logical pattern and progression in arranging ideas in conjunction with that purpose are essential to scientific communication. Almost any scientific report can use the

following generic outline as a model, but you must organize details within this pattern:

I. Introduction
- *A. The subject and organizational points*
- *B. Background and justification*
- *C. Objectives of the study*

II. Materials and Methods
- *A. Materials for the experiment*
- *B. Procedures and processes*
- *C. Data collection and analysis*
- *D. Statistical evaluations*

III. Results and Discussion
- *A. Synopsis of results*
- *B. Presentation of data (tables, figures, and supporting text)*
- *C. Discussion of significance, application, and relationship to similar studies*

IV. Conclusions

Once you have put real content into such a generic outline, the other essential point in organization is transition from one idea to another.

A1.3 INAPPROPRIATE CONTENT

A1.3.1 Too Much for One Paper

Excess may come with the paper's covering too many diverse points; containing too much material; having too much speculation; being too wordy, redundant, or repetitious; or being overloaded with data that could be expressed in representative samples.

A1.3.2 Too Little in One Paper

Scientists are far more likely to put too much in a paper than too little, but a lack of detailed development of specific points is also common.

A1.4 POOR STRUCTURE AND UNITY

Closely related to organization, unity within segments (sections, paragraphs, and sentences) as well as the transitions between units is vital to successful construction of the entire paper. Weaknesses in smaller units of the paper occur both in the presentation of data and in sentence construction.

A1.4.1 Data

Failure to achieve reader-friendly tables and figures occurs when they contain too little explanation or too many data. They may be arranged in an

unconventional order, have poor or faulty headings and legends or axis labels, be too complex or cluttered, or be unable to stand alone without the text.

A1.4.2 Sentence Construction

Sentences can and should be constructed in a variety of ways. Look at the following sentences; they all say essentially the same thing:

a. *Some strata of the earth contain water.*
b. *Water is present in some strata of the earth.*
c. *Rock and sand strata of the earth may hold water deposits.*
d. *Water has been deposited in the earth's strata.*
e. *There is water in rock and sand strata of the earth.*
f. *Contained within the depths of the earth are extensive strata composed of rock, gravel, or sand, some of which collected large deposits of water billions of years ago and still hold those deposits today.*
g. *Deposits called groundwater exist in rock and sand strata of the earth.*
h. *Underground are deposits of water.*
i. *Hidden in the monstrous recesses of the interior of the earth lie extensive strata of rock and sand wherein there exist enormous volumes of water.*

A dozen other versions of this information could be composed. No single construction is best except in the context in which it appears. Two frequent problems in sentence construction are wordiness and misplaced elements.

Wordiness often comes with failure to start with primary words. Look at the following example that was written by a graduate student:

It can be noted that salmonellae are present during all phases of poultry production and processing. Although similar hygiene practices were practiced on all of the 10 poultry farms we examined in this study, great variation existed in the degree of salmonella contamination on them. From the results of this study, it appears that salmonellae may be transmitted continuously through feed to the breeder parent stock, to the chicks, through the processing and finally to the finished broiler product.

We can communicate the same message as follows:

Salmonellae are transmitted progressively from feed to breeder chickens and their offspring and then through the processing plant to the finish product. On 10 poultry farms using similar production practices, we found great differences in the degree of salmonella contamination.

The two ideas in these sentences need further development, probably in separate paragraphs. It would really not matter which of the sentences was developed first or last. We can get rid of the repetition of such things as "*in this study*," "*practices were practiced*," and "*all phases of poultry production and processing*." We can also omit rather meaningless phrases such as "*It can be noted that …*" or "*it appears that.*" The result is that we have cut the length

almost in half, and our two points are more prominently displayed and ready to be developed with supporting details.

Misplaced elements in sentence construction interfere with smooth reading or logical sequence of ideas. Again, students have furnished examples:

Neither callus tissue from the spinach culture in 1988 nor 1989 produced shoots.

Logically, the "Neither … .nor" should be connecting only the years. The sentence could become

Callus tissue from the spinach culture produced shoots in neither 1988 nor 1989.

And another student wrote,

Our purpose was to determine whether the cultivar was more tolerant than others to the pathogen and to characterize the wilt.

Notice how "*to the pathogen*" and "*to characterize the wilt*" sound almost like parallel ideas until we give them a second thought. Actually, the parallel elements are "*to determine*" and "*to characterize*," and the sentence reads more smoothly if we put the shorter element closer to the verb and write

Our purposes were to characterize the wilt and to determine whether the cultivar was more tolerant than others to the pathogen.

A1.5 DISTRACTING LITTLE THINGS

The reader's attention is distracted by small inconsistencies and errors. Be consistent. Follow a style sheet. Is it Figure, figure, Fig, fig, Fig., fig., or *Figure, figure, Fig, fig, Fig.,* or *fig.* The term might even be written in other ways with underlining or boldface. Hyphens and numbers are used in a variety of ways—for example, *a 3-cm depth, 3 cm deep, two rates, a 2-mg rate, six plants, 42 plants.* Decide which forms to use relative to your publisher's style, and use little elements such as abbreviations, hyphens, numbers, and capitalization accurately and consistently.

Errors and inconsistencies in bibliographies and textual citations are distracting and may cause a reader to fail to find a reference. Follow publishers' styles and grammatical standards, and be sure textual citations coordinate with the entries in the list of references. Misspellings, faulty punctuation, and grammatical errors or inconsistencies anywhere in the text or bibliography can be frustrating to a reader. Proofread.

A1.6 SENSITIVITY TO WORDS (DICTION)

Watch out for words with similar meanings or forms. Use the best one available. Dangers exist with the following: *affect*, *effect*; *medium*, *media*; *data*, *datum*; *different*, *varying*; *while*; *only*; *cheap*, *economical*, *inexpensive*; *there is*;

a small size or a red color; and numerous other words. Avoid the use of groups of words that express the same meaning as a single word. For example, *at this point in time* means *now*, and *a long time period* means *a long time*. Proofread carefully, and do not trust a computer spell-check entirely. Believe it or not, the following have appeared in papers I have reviewed. They were probably all spell-checked:

- *This system has been wildly applied by most laboratories in the United States …*
- *The amount of plant material … was not sadistically different between years …*
- *Cotton responds to both soil moisture and relative humility.*
- *Magnesium sulfate had a notorious decrease on the value of moisture absorbed.*

Reading your work aloud and slowly will often call your attention to such oversights and make you smile before an audience laughs out loud.

Appendix 2

The First Draft

The following simple, rough essay was written as a result of a challenge from some undergraduates who assured me that no one can write an answer to an essay question in 10–15 minutes. I limited myself to10 minutes. I chose a subject that I know something about, but we assume that you know much about your subjects. My answer is crude and far from perfect. It ends abruptly, and I can think of many things I could have used better than some points I did use. If I were writing a real paper on this subject, this draft would simply provide me a beginning.

Read through the essay and then note the analysis that follows it. Rather than finding fault with this essay, look at what is good about it. I immediately go to a comparison/contrast and an enumeration approach. The "good and poor" and "points" in the initial question tell me to use these approaches, but notice that I also use definition and even imply cause–effect. Rather than waste time pondering all sorts of possibilities, I start with obvious general points that are important in a saddle (materials and workmanship). Later, I thought of a third important point (the job the saddle is designed to do). I work the third point in as best I can. In this rough draft, I will not worry about the point not being introduced, but in revision I will certainly add it to the two points in the first sentence. From my main points, I went to more specific examples, getting down to tangible pieces of a saddle (tree, rawhide, and stirrup leathers). Such elements of support are necessary in a good essay—always! Notice that my concluding remark would have been worthless without the support of the roping saddle. The essay contains good transitions at the beginnings of the second and third paragraphs, and the first sentence in each designates the topic for those paragraphs.

Note also many things that require revision. Sentences lack variety in construction; verbs and other terminology are weak. Ideas need further development. Also, I need to determine whether my audience will understand the saddle jargon and define more terms if they need definition. Along the way, I shifted from third person to second person. That too should be revised, but we will not worry about it in a first draft. And I will need a better conclusion that

reiterates all three of my main points; for example, "… is up to the job and is well crafted from quality materials." Get a rough draft of your paper done with attention to organization and development, and then the real work can begin.

Read through the first version of the essay, and then study the dissection of it that follows.

WHAT POINTS DISTINGUISH A GOOD WESTERN SADDLE FROM A POOR ONE?

Materials and workmanship distinguish a good saddle from a bad one. A good saddle will be made on a quality tree with good leather. The saddle tree is the form on which the saddle is built. No saddle is stronger than the foundation. Rawhide covered wood and molded fiberglass are the strongest trees on the market today. Canvas-covered trees or those with rawhide bindings should be avoided. The leather should be thick and flexible, especially at points of strain (stirrup leathers, rigging, etc.). Thin leather that is heavily hand-tooled is weakened by the tooling. Decorative metal can also weaken leather.

In addition to good materials, the saddle must be put together well. Note whether the leather on the seat is all one piece or is weakened by being sewed together. If possible, check to see how the rigging is attached and be sure that stirrup leathers are one solid piece laced around the tree rail and running the length of the fender. Even check to see where screws, nails, or weaker staples are used.

If the workmanship and materials are satisfactory, buy the saddle on the basis of comfort and application to the job. An uncomfortable saddle is not a good one. Sit in it before you buy if you can. If you plan to rope from it, check the horn and swell carefully to see that they will fit that job. A good saddle is one that not only looks good, but is up to a job. (time)

WHAT POINTS DISTINGUISH A GOOD WESTERN SADDLE FROM A POOR ONE?

(*enumeration*) (*comparison/contrast*)
Materials and workmanship distinguish a good saddle from a bad one. A
(***Point 1:*** *topic sentence*)
good saddle will be made on a quality tree with good leather. The saddle tree is
(*definition*)
the form on which the saddle is built. No saddle is stronger than the foundation.
(*enumeration of examples*)
Rawhide covered wood and molded fiberglass are the strongest trees on the
(*contrast*)
market today. Canvas-covered trees or those with rawhide bindings should be
(*enumeration of details*)
avoided. The leather should be thick and flexible, especially at points of strain

(*Tangible examples*) (*contrast*) (*detail*)
(stirrup leathers, rigging, etc.). Thin leather that is heavily hand-tooled is
(*detail*)
weakened by the tooling. Decorative metal can also weaken leather.
(*transition*) (***Point 2:*** *topic sentence*)
In addition to good materials, the saddle must be put together well. Note
(*example*) (*contrast*)
whether the leather on the seat is all one piece or is weakened by being sewed
(*example*)
together. If possible, check to see how the rigging is attached and be sure that
(*example*) (*tangible details*)
stirrup leathers are one solid piece laced around the tree rail and running the
(*tangible details/examples*)
length of the fender. Even check to see where screws, nails, or weaker staples
are used.
(*transition*)
If the workmanship and materials are satisfactory, buy the saddle on the
(***Point 3:*** *details*) (*contrast*)
basis of comfort and application to the job. An uncomfortable saddle is not a
(*example*)
good one. Sit in it before you buy if you can. If you plan to rope from it, check
(*details*)
the horn and swell carefully to see that they will fit that job. A good saddle is one
(*generalization*)
that not only looks good, but is up to a job. (time)

Appendix 3

Sample Manuscript

The following is an overly simple, abbreviated, fictitious manuscript for publication in a hypothetical journal. Studies that you pursue in science will probably be much more complex than this study, and your resulting manuscript will also be more complex. You may even find my information questionable. My purpose, however, is not to be scientific but, rather, to illustrate the pattern of organization and the techniques for development that should hold true for almost any scientific manuscript. The species, pokeweed, that this study uses is a real plant. People do eat it with preparation to eliminate toxicity. However, the study, the data, and the citations are entirely fictitious and serve simply to illustrate my points about organization and development. The manuscript should be considered as a draft in need of reviews and further revision.

OUTLINE*

Title: Emergence, Yield, and Quality of Poke Greens from Seeds and Roots

- ***I.*** *Introduction*
  - ***A.*** *Definition and research problem*
  - ***B.*** *Description of uses*
    - ***1.*** *Home preparation*
    - ***2.*** *Commercial use*
  - ***C.*** *Problems with propagation*
    - ***1.*** *Seeds*
      - ***a.*** *Germination*
      - ***b.*** *Preconditioning*
    - ***2.*** *Roots*
      - ***a.*** *Habitat*
      - ***b.*** *Handling*
  - ***D.*** *Purpose and objectives*

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* See also the generic outline in Appendix 1.

- ***II.*** *Materials and Methods*
    - ***A.*** *Materials*
        - ***1.*** *Seeds*
            - ***a.*** *Source*
            - ***b.*** *Storage*
        - ***2.*** *Roots*
            - ***a.*** *Source*
            - ***b.*** *Storage*
    - ***B.*** *Procedures*
        - ***1.*** *Treatments*
            - ***a.*** *Seeds*
                - ***(1)*** *Hot water*
                    - ***(a)*** *Time*
                    - ***(b)*** *Temperature*
                - ***(2)*** *Sulfuric acid*
                    - ***(a)*** *Time*
                    - ***(b)*** *Concentration*
                - ***(3)*** *Controls*
            - ***b.*** *Roots*
                - ***(1)*** *Size*
                - ***(2)*** *Weight*
        - ***2.*** *Plantings*
            - ***a.*** *Seeds*
            - ***b.*** *Roots*
    - ***C.*** *Data collection*
        - ***1.*** *Emergence*
        - ***2.*** *Dimensions: height, weight, stem diameter*
    - ***D.*** *Statistical analysis*
- ***III.*** *Results and Discussion*
    - ***A.*** *General outcomes*
    - ***B.*** *Specific outcomes*
        - ***1.*** *Emergence*
            - ***a.*** *Roots*
            - ***b.*** *Seeds*
        - ***2.*** *Quality comparison*
- ***IV.*** *Conclusion*

MANUSCRIPT

Emergence, Yield, and Quality of Poke Greens from Seeds and Roots

Abstract: As commercial value of poke greens increases, so does the need for methods of propagating pokeweed (*Phytolacca americana*) for commercial

production. We evaluated roots and seeds relative to emergence of shoots and yield and quality of greens produced. Roots were stored in peat moss until planted in three 4-m rows 30 cm apart. Seeds treated with sulfuric acid or hot water soakings were planted in three 3-m rows, and seedlings thinned to 20 cm after emergence. Untreated seeds served as controls, but emergence was negligible, and data were not useful. Shoots emerged from 87% of the roots and from 67 and 32% of seeds from acid and water soakings, respectively. We harvested 10 randomly selected plants from each treatment 2 weeks after emergence. Seedlings and shoots from roots were not significantly different in height, but shoots from roots had thicker stems and weighed significantly more at 120 g per 10 shoots than did seedlings at 70 g per 10 shoots. With more acceptable quality shoots, roots may be suitable for producing commercial greens and acid-scarified seeds for producing root beds for transplanting.

INTRODUCTION

Pokeweed (*Phytolacca americana*), also called poke salad or poke greens, is a perennial herb that reproduces by seeds or roots. Although uncooked they are toxic to humans, the young shoots and leaves are often parboiled and washed to remove the toxicity and then cooked for greens whose appearance and taste are similar to those of spinach. Canners suggest that the greens could be a nutritious and marketable alternative to other greens, but adaptation of the species from the wild to commercial growing conditions has been largely unsuccessful. If propagation methods can be found that produce quality greens, these could fill a timing niche for canning early in the spring before other crops are ready to process.

In spite of the extra parboiling step in processing, the popularity of poke greens is rather widespread (Smith, 2006), and canners are eager to explore the market. Even now canning companies in Northwest Arkansas find the commodity profitable enough to pay premium prices for fresh poke greens delivered from their wild habitats to canneries on days specified for their canning. The S & A Canning Company processed over 75,000 cans of poke greens last spring that stayed on grocery shelves an average of only 3 weeks, and the company would like to be able to expand this market (personal communication, Jim Simon, S & A Canning Company, Watts, OK). Acquiring enough poke greens for canning by gathering them from native habitats is unlikely to satisfy the demand.

This obstacle could be overcome if the species could be propagated and grown domestically. Until now, propagation and cultivation have been impractical because of poor germination of the seeds and the difficulty in acquiring roots and keeping them viable for planting. Under natural conditions seeds are seldom viable until they have been digested by birds. In 2002, Evans hypothesized that the seeds that germinate in the wild might be preconditioned in digestive tracts of birds. He collected feces of caged English sparrows fed

poke berries and found that seeds from these feces germinated 73% compared with 2% germination for untreated seeds. Lanier and Sizemore (2006) treated pokeweed seed in a hot water bath and achieved 27% germination. Further work on preconditioning seeds might reveal times and temperatures for water or acid treatment that could be even more effective. However, when they are tender enough for greens, shoots produced from seed are typically small with narrow stems (Evans, 2002).

Stems from roots are broader and more succulent, but acquiring the roots is also difficult. Pokeweed often grows in locations that are difficult to reach, and the taproots are very large and lie deep in the soil and subsoil. With a backhoe, Jones et al. (2001) acquired taproots that measured up to 23 cm wide and 35 cm long. The tops of them were typically located about 8 to 14 cm below the soil surface, and the full root extended as much as 48 cm deep. The roots are fleshy and dehydrate quickly if left exposed to the atmosphere (Evans, 2002). Although far more difficult than seed to acquire and preserve, roots typically produce shoots with thick fleshy stems and relatively large leaves compared with those grown from seeds. Quality of the canned product is superior if at least half the greens are grown from roots (Smith, 2006).

The purpose of our study was to determine the feasibility of propagating and producing quality greens from pokeweed to contribute to an expanded market for the greens. Our objectives were (1) to evaluate germination of pokeweed seeds treated with hot water and sulfuric acid, (2) to determine the feasibility of acquiring and storing roots to successfully grow shoots from them, and (3) to assess the quality of greens produced from both seeds and roots.

MATERIALS AND METHODS

The experiments were conducted in the field at the Western Arkansas Agricultural Experiment Station near Mena in spring of 2006 and 2007. Seeds and roots were acquired from an abandoned field on the Rex Mofield farm near the station. Fully ripened berries were gathered in October of the year before planting and stored at 5°C. Roots were excavated with a backhoe in January of each year, packed in peat moss, and stored at 5°C.

Treatments

Seeds from berries, equilibrated to room temperature overnight, were treated with hot water or sulfuric acid. In a hot water bath, seeds were soaked for 1.5 h at a temperature maintained at 80°C or for 8 h at 60°C. For the sulfuric acid treatments, we used 10% sulfuric acid in tap water held at 25°C. Seeds were soaked in this treatment for 15 or 30 min. Seeds for the controls were held in cold tap water for 30 min just before they were planted.

Roots measured 11 to 21 cm wide and 24 to 32 cm long. Each remained surrounded by at least 6 cm peat moss until removed for immediate planting.

For the 2006 test, roots had been stored for 4 weeks and in 2007 for 6 weeks. Initial weights taken before storing and at removal from the peat moss indicated an average weight loss of less than 10 g per root.

Both seeds and roots were planted on February 15 in 2006 and on February 27 in 2007. The soil is a Bjorn silt loam, and standard soil tests revealed adequate fertility for optimum pokeweed growth as determined by Hurter and Balou (2005). The plots had been plowed the previous fall, and during the experiment, they were weeded of all species except the pokeweeds. Rainfall supplied adequate moisture for growth.

For each seed treatment and the control, seeds were planted about 1 to 2 cm deep and 5 cm apart in three 3-m rows with each row considered a replication. Rows were 0.5 m apart. Eight days after first emergence, they were thinned to one plant per 20 cm, and any plants that emerged thereafter were rogued. Three rows for roots were 4 m long, and roots were planted 30 cm apart with the top of the root 10 cm deep in the soil.

Percentage emergence for both seeds and roots was determined at 24 days after planting. Most shoots and seedlings had emerged within 18 days. Plants grew for 2 additional weeks, at which time 10 plants randomly selected from each treatment were measured for height from the soil surface and cut 2 cm above soil surface to determine weights. Stem diameter was measured at that cut.

Because emergence from the controls was negligible with only one emerged in 2006 and three in 2007, these were disregarded and comparisons made between roots and seed treatments. Treatments were compared by analyzing data for percentage emergence and plant height, weight, and stem diameter with least significant difference at the 0.05 level.

RESULTS AND DISCUSSION

Percentage emergence from roots was greater than that from seeds, and quality from roots, as determined by weight and stem diameter, was superior to that of seedlings. For the data combined over the 2 years, shoots from roots emerged 87% with only 4 of the 32 roots failing to produce shoots. Storage in the peat moss apparently preserved their viability. Jones et al. (2001) found that only two of eight roots kept for 3 weeks in a wooden basket at room temperature produced shoots. Of their two viable roots, one produced two shoots and the other produced one. Of the 28 roots in our study that did develop shoots, 17 produced three to five shoots, 7 produced two shoots, and the other 4 had one each. Size of the root appeared to have no influence on the number of shoots or the size at harvest.

Emergence from seeds treated with sulfuric acid was significantly greater than those from hot water baths (Table A3.1). Averaged over the 2 years, data showed 73% emergence for the sulfuric acid treatment for 15 min (0.25 h) compared with significantly less at 61% for the 30-min (0.50 h) treatment. This difference might indicate that the acid produced a deleterious effect with

TABLE A3.1 Percentage Emergence of Pokeweed from Seeds and Roots (Average from 2 Years)

Source Treatment (hours/°C)	Emergence (%)		
	2006	2007	Mean[1]
Roots	83	91	87a
Seeds			
Hot Water			
1.5/80	20	38	29c
8.0/60	24	44	34c
10% Sulfuric Acid			
0.25/25	68	78	73b
0.50/25	57	65	61b

[1]*Means followed by the same letter are not significantly different at 0.05.*

TABLE A3.2 Two-Year Average Yield by Weight, Height, and Stem Diameter of Pokegreen Plants from Roots and Shoots (Averages for 10 Plants per Treatment per Year)

Source	Weight (g)	Height (cm)	Stem Diameter (cm)
Roots	120a[1]	16.7a	1.3a
Seeds	70b	18.2a	0.4b

[1]*Means followed by the same letter are not significantly different at 0.05.*

time, and further testing might find an even more optimal time than 15 min. Hot water baths did not produce results significantly different from each other, but seeds from either emerged significantly less than from acid treatments with 29% from the 1.5-h soaking and 34% from the 8-h soaking. The somewhat greater emergence from the hot water baths in 2007 than in 2006 may be attributed to weather conditions and the seeds being planted later in 2007.

Heights of seedlings and of shoots from roots were not significantly different, but weights and stem diameters were decidedly different (Table A3.2). Shoots from roots were obviously more fleshy at 120 g per 10 shoots compared with the 70 g for 10 seedlings, and they adhered more fully to Smith's (2006) description of preferred greens for canning.

CONCLUSIONS

Our research indicated that the roots were kept viable for transplanting with storage in peat moss, and that acid scarification significantly increased germination of seeds. The higher quality of shoots produced from roots suggests that greens produced perennially from an established field of roots would be preferred over greens grown from seedlings. Acquisition of roots from the wild is still a major hurdle for commercial production. Acid scarified seeds might be used to establish beds in which to develop roots for transplanting. Further research is needed to establish optimal treatments for seeds and to determine the longevity of production from initially transplanted roots. An expanding market for the canned product may make such research practicable.

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Appendix 4

Sample Literature Review

The following literature review was written by Terry Gentry (then a graduate student, now a professor) in conjunction with his graduate proposal in Appendix 5. Like any good literature review, it serves (1) as an introduction to the study, (2) as background information to make the study more meaningful to the researcher as well as the reader, and (3) as justification for the study. Like the study itself, it introduces the problem (polycyclic aromatic hydrocarbon contamination) and possible solutions to the problem (dissipation and remediation) with emphasis on the solution proposed in the study (phytoremediation with microorganisms in the rhizosphere). Organization and content for the review are focused around these key issues, which can be used as the key words for the literature search that provided the content. Note that the review is not just a listing of studies done in the area but a smooth flow of information in the form a discussion of the issues with appropriate references interspersed. See how Mr. Gentry moved from the general subject to those areas specifically related to his own and ends with a concluding justification for his own study. Also note how he has used headings and transitions to lead the reader through the review.

POLYCYCLIC AROMATIC HYDROCARBON INFLUENCE ON RHIZOSPHERE MICROBIAL ECOLOGY

Contamination of soil by toxic organic chemicals is widespread and frequent. This is sometimes the result of large-scale incidents such as the Exxon Valdez oil spill in Alaska (Pritchard and Costa, 1991). But, more often, smaller areas of soil are polluted. Cole (1992) estimated that in the United States there are 0.5 to 1.5 million underground storage tanks leaking into the surrounding soil. *In situ* bioremediation of these contaminated sites may be more feasible than chemical and physical cleanup methods. Degradation of polycyclic aromatic hydrocarbons (PAHs), a major constituent of many of these pollutants, can be possible if PAH-degrading microorganisms are present at the site. These microorganisms may be more prolific in the rhizosphere of plants than in soil with no vegetation.

A. Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons are organic compounds that are typically toxic and recalcitrant (Sims and Overcash, 1983). They consist of at least three benzene rings joined in a linear, angular, or cluster array (Cerniglia, 1992). Edwards (1983) described PAHs as being practically insoluble in water. They are produced by various processes including the incomplete combustion of organic compounds such as petroleum (Giger and Blumer, 1974; Laflamme and Hites, 1978). The carcinogenicity of many PAHs has been well documented (Haddow, 1974). This knowledge has prompted much research to determine the mode by which these compounds cause cancer and their ultimate health risks to humans (Miller and Miller, 1981). Due to their toxic nature, the United States Environmental Protection Agency included several PAHs in their list of priority pollutants to be monitored in industrial wastewaters (Keith and Telliard, 1979). Heitkamp and Cerniglia (1988) concluded that this interest has resulted in increased efforts to remediate PAH-contaminated soil.

B. Dissipation

Reilley et al. (1996) reported the fate of PAHs in soil includes irreversible sorption, leaching, accumulation by plants, and biodegradation. They also contended that surface adsorption is the main process controlling PAH destination in soil. Many PAHs are strongly adsorbed to soil particles (Knox et al., 1993). Means et al. (1980) found the PAHs composed of longer chains and greater masses to be more strongly adsorbed to soil particulate matter. Leaching of PAHs from soil is minimal due their adsorption to soil particles and low water solubility (Reilley et al., 1996). Results indicate that larger PAHs may adsorb onto roots, but translocation from roots to foliar portions of the plants is negligible (Edwards, 1983; Sims and Overcash, 1983). Biodegradation is the main pathway by which dissipation can be enhanced.

C. Bioremediation

Bioremediation manipulates biodegradation processes by using living organisms to reduce or eliminate hazards resulting from accumulation of toxic chemicals and other hazardous wastes. According to Bollag and Bollag (1995), two techniques that may be used in bioremediation are (1) stimulation of the activity of the indigenous microorganisms by the addition of nutrients, regulation of redox conditions, optimization of pH, or augmentation of other conditions to produce an environment more conducive to microbial growth and (2) inoculation of the contaminated sites with microorganisms of specific biotransforming abilities.

1. Indigenous Population. Soil contains a large and diverse population of microorganisms (Tiedje, 1994). The indigenous population of these microorganisms has been manipulated to increase biodegradation. *In situ*

bioremediation utilizes organisms at the site of pollution to remove contaminants. Often, indigenous organisms from the contaminated area, which may even have adapted to proliferate on the chemical, are utilized to remove the pollutants (Bollag and Bollag, 1995).

Microbial degradation may be enhanced by aeration, irrigation, and application of fertilizers (Lehtomäki and Niemelä, 1975). In Prince William Sound, Alaska, following the Exxon Valdez oil spill, the application of fertilizers increased biodegradation up to threefold (Pritchard and Costa, 1991).

The relative contributions of bacterial and fungal populations to hydrocarbon mineralization may differ based upon contaminant and soil parameters. Anderson and Domsch (1975) studied the degradation of glucose in several soils. They attributed the majority of mineralization to fungi (60–90%) with relatively minor bacterial contribution (10–40%). It is unclear if fungi are also the principal degraders of hydrocarbons (Bossert and Bartha, 1984). Song et al. (1986) reported 82% of *n*-hexadecane mineralization was due to bacteria while fungi contributed only 13%. They concluded that bacteria are the primary degraders of *n*-hexadecane in the soil tested, but additional experiments are necessary before the results can be generalized. In a field study utilizing six oils as contaminants, Raymond et al. (1976) noted that fungi appeared to be the principal hydrocarbon-degraders.

From a review of the literature, Cerniglia (1992) found various bacteria, fungi, and algae reported to degrade PAHs. More specifically, Déziel et al. (1996) isolated 23 bacteria capable of utilizing naphthalene and phenanthrene as their sole growth substrate. These bacteria were all fluorescent pseudomonads. Shabad and Cohan (1972) reported that soil bacteria are the primary degraders of PAHs. Cerniglia's (1992) review concluded that the microbial degradation of smaller PAHs such as phenanthrene has been thoroughly investigated; however, there has not been sufficient research on the microorganisms capable of degrading PAHs containing four or more aromatic rings. There remains a need for isolation and identification of microorganisms capable of degrading the more persistent and toxic PAHs (Cerniglia, 1992).

2. Introduced Microorganisms. Organisms capable of breaking down certain pollutants are not present at all sites; therefore, inoculation of the soil with microorganisms, or bioaugmentation, is sometimes required (Alexander, 1994). Indigenous or exogenous microorganisms may be applied to the polluted soil (Turco and Sadowsky, 1995). Microorganisms capable of degrading several pollutants including PAHs have been isolated from contaminated soil (Heitkamp and Cerniglia, 1988). In addition, Lindow et al. (1989) communicated a need for the continued development of genetically engineered microorganisms including those capable of degrading a variety of pollutants. Nevertheless, successful establishment of introduced microorganisms remains enigmatic (Pritchard, 1992; Turco and Sadowsky, 1995). Thies et al. (1991) linked the poor survival of introduced microorganisms to competition from native soil microorganisms.

The characteristics that allow introduced microorganisms to become acclimated to a new environment have not been completely elucidated (Turco and Sadowsky, 1995). However, the indigenous soil populations appear to have specific qualities, such as the ability to utilize a particular growth substrate, that give them a competitive advantage in occupying available niches (Atlas and Bartha, 1993). One way to encourage the growth of introduced microorganisms may be to supply a new niche for microbial growth in the form of a suitable plant.

D. Phytoremediation

Phytoremediation is defined by Cunningham and Lee (1995) as "the use of green plants to remove, contain, or render harmless environmental contaminants." This applies to all plant-influenced biological, microbial, chemical, and physical processes that contribute to the remediation of contaminated sites (Cunningham and Berti, 1993). Plants have historically been developed for food or fiber production. With an increasing interest in the use of plants to reduce contamination from organic chemicals, plants may be selected and developed based upon their suitability for bioremediation. Cunningham and Lee (1995) contend that plant attributes such as rooting depth, structure and density can be altered to increase biodegradation. They assert that if contaminants are (1) in the upper portion of the soil, (2) resistant to leaching, and (3) not an immediate hazard, many may be removed by phytoremediation. Experiments may confirm that phytoremediation is a less expensive, more permanent, and less invasive technique than many current methods of remediation (Cunningham and Lee, 1995).

E. The Rhizosphere

Curl and Truelove (1986) have described the rhizosphere as the zone of soil under the direct influence of plant roots and in which there is an increased level of microbial numbers and activity. They report that the ratio of bacteria and fungi in the rhizosphere to the non-rhizosphere soil (R/S ratio) commonly ranges from 2 to 20 due to the root exudation of easily metabolizable substrates. These exudates include sugars, amino compounds, organic acids, fatty acids, growth factors, and nucleotides (Curl and Truelove, 1986). Legumes usually demonstrate a greater rhizosphere effect than non-legumes (Atlas and Bartha, 1993). Also, the development of plant roots in previously nonvegetated soil may alter soil environmental conditions including carbon dioxide and oxygen concentrations, osmotic and redox potentials, pH, and moisture content (Anderson and Coats, 1995).

Generally, the rhizosphere is colonized by a predominantly gram-negative bacterial community (Curl and Truelove, 1986). Anderson and Coats (1995) reported that one of the interesting and repeated topics discussed

during the 1993 American Chemical Society symposium was the prevalence of gram-negative microorganisms in the rhizosphere. Reportedly, the ability of gram-negative bacteria to quickly metabolize root exudates contributes to their predominance in the rhizosphere (Atlas and Bartha, 1993).

Anderson and Coats (1995) suggest that increased rates of contaminant degradation in the rhizosphere compared to nonvegetated soil may result from increased numbers and diversity of microorganisms.

1. Rhizosphere Effect on PAHs. The rhizosphere of numerous plants has been reported to increase the biodegradation of several PAHs. Aprill and Sims (1990) examined the effects of eight prairie grasses (*Andropogon gerardi*, *Sorghastrum nutans*, *Panicum virgatum*, *Elymus canadensis*, *Schizachyrium scoparius*, *Bouteloua curtipendula*, *Agropyron smithii*, and *Bouteloua gracilis*) on the biodegradation of four PAHs, benzo(*a*)pyrene, benz(*a*)anthracene, chrysene, and dibenz(*a*,*h*)anthracene. They reported significantly greater disappearance of the PAHs in the vegetated soils compared to the unvegetated soils, and the rate of disappearance was directly related to the water solubility of each compound.

Reilley et al. (1996) investigated the rhizosphere effect of alfalfa (*Medicago sativa* L.), fescue (*Festuca arundinacea* Schreb.), sudangrass (*Sorghum vulgare* L.), and switchgrass (*Panicum virgatum* L.) on the degradation of pyrene and anthracene. They reported that the vegetation significantly increased the degradation of these PAHs in the soil. They concluded that degradation most likely resulted from an elevated microbial population in the rhizosphere due to the presence of root exudates.

Nichols et al. (1996) conducted an experiment on the degradation of a model organic contaminant (MOC) composed of six organic chemicals including two PAHs (phenanthrene and pyrene) in the rhizospheres of alfalfa (*Medicago sativa*, var. Vernal) and alpine bluegrass (*Poa alpina*). They found increased numbers of hydrocarbon-degrading microorganisms in the rhizospheres of both plants. From the same study, Rogers et al. (1996) reported that plants demonstrated no significant impact on the degradation of the MOC. They concluded it was probable that biological and/or abiotic processes occurring before plants developed enough to produce a rhizosphere effect were responsible for the disappearance of the MOC compounds.

2. Rhizosphere Microbial Ecology in PAH-Contaminated Soil. Before microorganisms can be successfully introduced into the soil or managed for increased bioremediation, an increased understanding of the determinants of rhizosphere microbial ecology needs to be developed. Anderson and Coats (1995) stated the need for an expanded understanding of the interactions between plants, microorganisms, and chemicals in the root zone in order to identify conditions where phytoremediation using rhizosphere microorganisms is most feasible.

To date, no studies have been conducted on rhizosphere microbial ecology in PAH-contaminated soil. Furthermore, little is known about the factors controlling rhizosphere microbial ecology in uncontaminated soil. Bowen (1980)

asserted the plant to be the predominant force in the rhizosphere system. In contrast, Bachmann and Kinzel (1992) reported that, in a study involving six plants and four soils, the soil was the dominant factor in some plant–soil combinations. A unique symbiosis that developed from the combination of a specific plant and soil microorganisms was evident. Of all tested plants, *Medicago sativa* had the strongest influence on the soil. They concluded that this effect was consistent with the results of Angers and Mehuys (1990) and may be related to the nitrogen-fixing activity of alfalfa.

Additionally, recent research suggests that gram-positive bacteria may be a larger component of the rhizosphere microbial population than previously reported. Cattelan et al. (1995) found a large percentage of soybean (*Glycine max*) rhizosphere population to be occupied by the gram-positive bacterial genus *Bacillus* spp. Also, it appears that gram-positive microorganisms may play a major role in the breakdown of contaminants including PAHs. Heitkamp and Cerniglia (1988) isolated a gram-positive bacterium capable of degrading several PAHs. The bacterium could not utilize PAHs as the sole C source, but it did completely mineralize PAHs when supplied with common organic carbon sources such as peptone and starch. Additional research is needed to elucidate the determinants of rhizosphere microbial ecology especially in PAH-contaminated soils.

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Appendix 5

Sample Graduate Proposal

The literature review in Appendix 4, the slide set in Appendix 13, and the following proposal are the work of Terry J. Gentry, a candidate at the time for the master's degree at the University of Arkansas–Fayetteville (used with permission of T. J. Gentry). Both the review of literature and the proposal were presented to his committee along with his proposed plan of course work. The slide set was used with a seminar presentation and also presented to his committee with his proposal. In addition, his preliminary work was used as the basis for a poster at a regional meeting.

Notice in this proposal the inclusion of the preliminary work, which is not always a part of a graduate proposal. The proposal could have been presented to the graduate committee prior to the preliminary work. In that situation, the proposal would contain two objectives, and conditions of the second objective and methods would depend on results from the first. With inclusion of the preliminary study here, however, Mr. Gentry has additional justification for his proposed study and has already determined the conditions on which the objective and methods will be based. The methods section of his "Proposed Experiment" can simply refer to that section of the "Preliminary Study." Otherwise, if the preliminary study were removed, it would still be a complete, unified proposal. Also, some graduate committees may want the literature review incorporated into the proposal. The following model, then, is not to be considered a set standard; individual proposals must fit the situation, the committee requirements, and the experimentation proposed.

POLYCYCLIC AROMATIC HYDROCARBON INFLUENCE ON RHIZOSPHERE MICROBIAL ECOLOGY

INTRODUCTION

Contamination of soil by toxic organic chemicals is widespread and frequent. This is sometimes the result of large-scale incidents such as the Exxon Valdez oil spill in Alaska (Pritchard and Costa, 1991). But, more often, smaller areas

of soil are polluted. Cole (1992) estimated that in the United States there are 0.5 to 1.5 million underground storage tanks leaking into the surrounding soil. Polycyclic aromatic hydrocarbons (PAHs) are a major constituent of many of these pollutants. These PAHs are characterized by their toxicity and persistence (Sims and Overcash, 1983).

Phytoremediation is a technology that may provide cheaper, more permanent and less invasive amelioration of these contaminated soils than other remediation methods (Cunningham and Lee, 1995). Curl and Truelove (1986) described the rhizosphere as the zone of soil under the direct influence of plant roots and in which there is an increased level of microbial numbers and activity. The rhizosphere of numerous plants has been shown to increase the biodegradation of various organic contaminants (Anderson and Coats, 1995). Aprill and Sims (1990) found increased disappearance of four PAHs in soil columns planted with prairie grass compared with nonvegetated soil columns. Reilley et al. (1996) reported an increased degradation of pyrene and anthracene in the rhizospheres of three grasses and a legume.

Although much work has been done on manipulating the soil microflora, little is known about the determinants of rhizosphere microbial ecology (Bachmann and Kinzel, 1992). Anderson and Coats (1995) suggest that a better understanding of the mechanistic interactions among plants, microorganisms, and chemicals in the root zone will help identify situations where phytoremediation can be appropriate.

In a preliminary study we assessed the diversity of microorganisms present in two soils without vegetation and in the rhizosphere of bahiagrass (*Paspalum notatum* Flügge, var. Argentine). The goal of the proposed study is to determine how populations of microorganisms in the rhizosphere respond to the presence of a PAH.

PRELIMINARY STUDY

The objective of the preliminary experiment was to assess the impact of bahiagrass rhizosphere on bacterial density and diversity in two soils.

Materials and Methods

The experiment was conducted under preset conditions on a Captina silt loam (fine-silty, siliceous, mesic Typic Fragiudults) at the University of Arkansas–Fayetteville and on an Appling sandy loam (clayey, kaolinitic, thermic Typic Kanhapludults) at the University of Georgia–Athens. Field moist samples from the Ap horizons of the soils were passed through sterile 2-mm sieves and stored at 4°C until the beginning of the experiment. Cone-tainers® were surface-sterilized by submerging in 30% bleach for 15 min and rinsing with sterile deionized water. Sterile cheesecloth patches were placed in the bottom of cone-tainers®. Sixty grams of moist soil (52.4 g dry weight) was weighed into

respective surface-sterilized cone-tainers® and incubated in growth chambers with day/night cycles of 16/8 h and 27/16 $\pm$ 1°C. For 2 weeks prior to planting, soils were maintained at 60% of -0.03 MPa (14.2% w/w) soil moisture potential with sterile distilled water.

To reduce plant genetic variability, bahiagrass, an apomictic plant, was selected for the experiment. One gram of seed was weighed into a scintillation vial. Ten milliliters of 95% ethanol was added to the seed and vortexed. Ethanol was removed from seed by pipette. The vial containing ethanol-cleaned seed was placed onto ice in an ice bucket. Ten milliliters of concentrated sulfuric acid was added to the vial. The seed were vortexed a few seconds every minute during the 8-min scarification process. Sulfuric acid was drawn off by pipette, and the seed were rinsed seven times with distilled water.

Scarified seed were surface-sterilized with 10 mL of 30% bleach solution added to the vial. Seed were sterilized for 30 min and were vortexed for a few seconds every 5 min. Bleach solution was drawn off, and 10 mL of sterile 0.01 *M* HCL was added to the vial, vortexed, and allowed to stand for 10 min. A pipette was used to remove the 0.01 *M* HCL from the vial, and the seed were rinsed with sterile distilled water six times. Sterile seed were inserted between moist sheets of sterile filter paper in Petri dishes and placed in an incubator at 30 $\pm$ 1°C. After 4 days, five germinated seeds were planted in respective, pre-incubated Cone-tainers® and covered with 1 cm of sterile sand. Cone-tainers® were returned to the growth chambers and maintained at the same conditions as prior to planting. Seedlings were thinned to one per Cone-tainer® after emergence. Bulk soil in control Cone-tainers® received no seed but was otherwise treated the same.

Plants were harvested 3 weeks after planting. Cone-tainers® were sectioned vertically with a sterile scalpel, and plant shoots were cut off at the soil surface. Soil was emptied onto sterile aluminum foil. Roots were carefully removed from the soil and lightly shaken against a sterile surface to remove loosely attached soil. Roots plus tightly adhering, rhizosphere soil were placed into 99-mL dilution blanks for the 10^{-2} dilutions. One gram of soil from the nonvegetated soil Cone-tainers® was utilized for the corresponding 10^{-2} dilutions of nonrhizosphere (bulk) soil. Samples were serially diluted and spread-plated on 1/10-strength trypticase soy agar (0.1 $\times$ TSA) containing 100 mg cycloheximide/L. Total numbers of aerobic, heterotrophic bacteria were determined after incubation of plates at 28 $\pm$ 1°C for 2 days (Wollum, 1994).

Approximately 60 well-separated bacterial colonies were randomly selected from each treatment: Captina bulk soil, Captina rhizosphere, Appling bulk soil, and Appling rhizosphere. Isolates were restreaked twice on 0.1 $\times$ TSA plates to check for purity before a final transfer to 1 $\times$ BBL brand TSA (Becton Dickinson and Co., Cockeysville, MD). After 24 $\pm$ 2 h of growth at 28 $\pm$ 1°C, about 40 mg of each isolate was extracted for fatty acid methyl ester (FAME) analysis (Sasser, 1990).

Extracts were sent to the University of Delaware and analyzed by gas chromatography with the MIDI system (MIDI, Newark, DE). Fatty acid profiles

TABLE A5.1 Total Bacterial Numbers in Bulk Soil and Bahiagrass Rhizosphere (Rhiz) of Captina and Appling Soils

Captina Silt Loam			Appling Sandy Loam		
Bulk	Rhiz	R/S*	Bulk	Rhiz	R/S
	10^6 CFU/g dry soil			10^6 CFU/g dry soil	
10.0 a**	11.0 a	1.1	5.8 a	18.3 b	3.2

**Ratio of rhizosphere/bulk soil populations.*
***For a given soil, numbers with the same lowercase letter are not significantly different at the 5% level.*

were compared with aerobic bacteria in the TSBA library from MIS Standard Libraries. A similarity index of ≥0.4 was considered a match for the genus (Kennedy, 1994; Sasser, 1990).

A 2-sample *t*-test was used to compare the total bacterial numbers in the bulk soil and rhizosphere for each soil. The distributions of bacterial genera for soil (Captina, Appling)–treatment (bulk soil, rhizosphere) combinations were compared by a chi-squared test for equality of distributions. Where small expected cell counts invalidated the usual chi-squared test, Fisher's exact test was used. The P values at ≤0.05 were considered significant.

Results and Discussion

Total numbers of soil bacteria for the bulk soil and bahiagrass rhizosphere of the Captina silt loam were 1.0×10^7 and 1.1×10^7 colony-forming units (CFU)/g of dry soil, respectively, and were not significantly different (Table A5.1). Similar data were recently reported for bulk soil and alpine bluegrass (*Poa alpinus*) rhizosphere of Captina silt loam (Nichols et al., 1996). The bluegrass demonstrated a slightly larger rhizosphere influence than the bahiagrass on the total number of bacteria, but this difference may have been partly due to the longer growth period utilized in that experiment.

In contrast, total bacterial numbers of the Appling sandy loam were 0.6×10^7 and 1.8×10^7 CFU/g dry soil in the bulk soil and rhizosphere, respectively, and were significantly different. A comparable increase in bacterial numbers has been shown for a soybean (*Glycine max*) rhizosphere in Appling sandy loam (Cattelan et al., 1995).

The observed rhizosphere influence on bacterial numbers was relatively small with R/S ratios of 1.1 for the Captina silt loam and 3.2 for the Appling sandy loam. Published data indicate that grasses typically exhibit low R/S ratios as compared to legumes (Curl and Truelove, 1986).

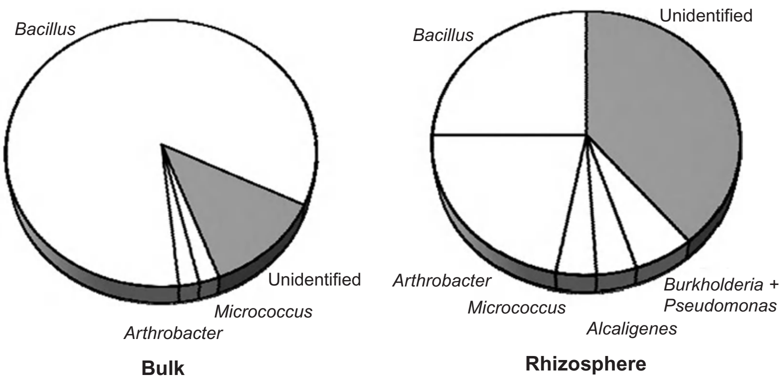

FIGURE A5.1 Relative proportions of bacterial genera isolated from the Captina silt loam bulk soil and bahiagrass rhizosphere.

Although there was no measurable difference in the total number of bacteria between the bulk soil and bahiagrass rhizosphere of Captina silt loam, there was a significant increase in diversity in the rhizosphere (Figure A5.1). The percentage of *Bacillus* spp. decreased from 84% in the bulk soil to 25% in the rhizosphere. Accordingly, the number of bacterial genera represented in the rhizosphere was increased with the appearance of *Alcaligenes* and *Burkholderia* + *Pseudomonas* spp. There was a concomitant increase in the proportion of *Arthrobacter* and *Micrococcus* spp. Also, the number of unidentified bacteria (similarity indices <0.40) increased from 12% in the bulk soil to 39% in the rhizosphere.

Despite the decrease in the percentage of *Bacillus* spp., the gram-positive bacteria *Bacillus* and *Arthrobacter* were dominant in the Captina bulk soil and rhizosphere. Only small numbers of gram-negative bacteria such as *Pseudomonas* were identified. These results differ from those reported by other investigators that gram-negative bacteria predominate in the rhizosphere (Curl and Truelove, 1986). The gram status of unidentified isolates has not been determined.

In contrast, Appling sandy loam demonstrated no significant change in bacterial diversity between the bulk soil and rhizosphere (Figure A5.2). Only three bacterial genera were identified in the bulk soil and in the rhizosphere. Identified bacteria were mostly *Bacillus* and *Arthrobacter* spp., and their numbers were relatively consistent at 21% and 10% in the bulk soil and 25% and 10% in the rhizosphere, respectively. The majority of the isolates from the bulk soil and rhizosphere were not identified, 68% and 63%, respectively. Cattelan et al. (1995) reported that there was no significant difference in the relative frequency of bacterial genera of the bulk soil and soybean rhizosphere of Appling sandy loam when sampled at 3 and 15 days after planting.

Again, in contrast to the reported data (Curl and Truelove, 1986) the gram-positive genera *Bacillus* and *Arthrobacter* comprised the majority of identified isolates from the bulk soil and rhizosphere of the Appling sandy loam.

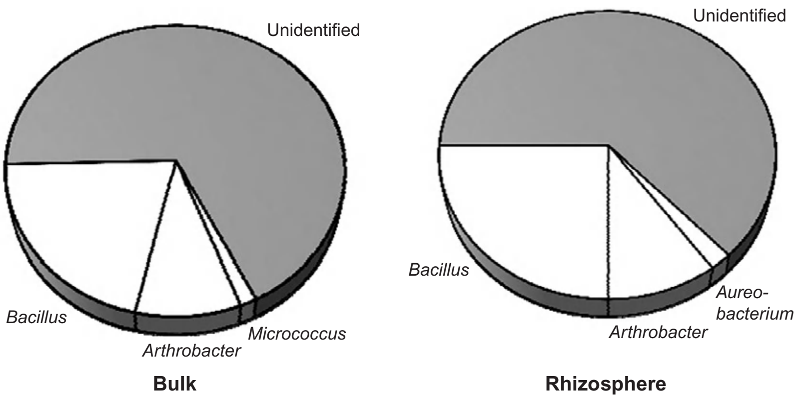

FIGURE A5.2 Relative proportions of bacterial genera isolated from the Appling sandy loam bulk soil and bahiagrass rhizosphere.

In addition, the gram status of a large, unidentified percentage of bacterial isolates has not been determined.

Conclusions

The data indicate that bahiagrass rhizosphere significantly increased the bacterial diversity in the Captina silt loam but did not influence the bacterial diversity in the Appling sandy loam. The soil appeared to impact the rhizosphere effect on bacterial diversity. More soils need to be tested to clarify these results. The total rhizosphere influence on bacterial numbers and diversity may be underestimated due to the inability to culture and/or identify a large portion of the soil bacterial population by current methods.

PROPOSED EXPERIMENT

With some knowledge of its microbial ecology from the preliminary experiment, Captina silt loam has been chosen as the soil to assess the influence of a PAH on the microbial ecology in the rhizosphere. Likewise, bahiagrass will be one of the plants studied. Alfalfa (*Medicago sativa*, var. Vernal), a legume, has been added to the study because of its demonstrated rhizosphere influence (Nichols et al., 1996). Pyrene, a four-ring PAH, will be the contaminant due to its recalcitrance in soil (Rogers et al., 1996).

Objective

The objective of this study is to determine the effects of pyrene on the rhizosphere microbial ecology of bahiagrass and alfalfa.

Materials and Methods

Treatments will be similar to those used in the preliminary study, and comparisons will be made between bulk soil, bahiagrass rhizosphere, and alfalfa rhizosphere with and without pyrene. The Captina silt loam will be collected and sieved through a sterile 2-mm sieve. Sieved soil will be stored at 4°C in Ziploc® bags until the experiment begins. Soil equivalent to 750 g dry weight will be added to glass 1.5-pint jars, which have been sterilized by rinsing once with 30% bleach solution and six times with water to remove residual bleach before soil is added.

Pyrene will be ground in a mortar and pestle, passed through a 250-μm sieve, and mixed into soil at a level of either 0 mg/kg or 2000 mg/kg. Controls with no pyrene will be used. Soil in jars will be pre-incubated for 2 weeks at room temperature. Soil is to be maintained at −0.03 MPa soil moisture potential by daily addition of sterile distilled water.

Bahiagrass and alfalfa seed will be germinated and planted into respective jars using procedures outlined in the preliminary study. Plants will be harvested 10 weeks after planting following procedures outlined in the preliminary study. Samples will also be spread-plated onto Martin's medium to determine the number of fungi and onto starch-casein agar to determine the number of actinomycetes (Wollum, 1994). Approximately 500 colonies each of the actinomycetes, bacteria, and fungi will be isolated from spread-plates and inoculated into Bushnell–Haas broth containing 50 mg/10 mL pyrene to determine whether the microbial isolates are capable of using pyrene as a sole C source and can degrade the compound. Pyrene in the rhizosphere and nonrhizosphere soil will be extracted and respective levels determined by gas chromatographic analysis.

Statistical analysis will be the same as those outlined in the preliminary study.

Conclusions

Much work has been done to determine the rhizosphere effect on the biodegradation of organic contaminants. Studies have attributed the increased degradation of several compounds in the rhizosphere of numerous plants to microorganisms. In contrast, very few studies have examined the effect of contaminants on the microbial ecology of the rhizosphere. An increased understanding of the microbial interactions in the rhizosphere may make possible more precise manipulation of the rhizosphere microbial population for the biodegradation of organic contaminants. These experiments should identify specific microorganisms capable of degrading the PAH pyrene. Additionally, the increased knowledge of rhizosphere microbial ecology in contaminated soil may lead to the selection of appropriate plants capable of stimulating an indigenous or introduced microbial population to enhance the remediation of contaminated sites.

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Appendix 6

Alternate Routes to the Thesis

Whether you write your thesis in the traditional format or with publishable journal articles, your ultimate goals are probably a degree, a publication, and a job or additional education. The thesis is only a part of the work that you must incorporate into your plans for the graduate program. Any one of a variety of plans can lead to your success with the thesis, and the road map presented here simply represents two examples (Figure A6.1). For simplicity, the routes are assuming a master's thesis that would take approximately 2 to 2.5 years to complete and would result in the publication of one journal article. A more complex doctoral dissertation or additional publications would extend the time and add to the workload but follow similar paths. Certainly, the order of events may be rearranged, especially toward the last when the thesis, the defense, the job, and the publication may all confront you at once. Be careful about entering a new degree program or taking a job before your thesis is complete.

You may feel that you are jumping over a series of hurdles as you move along your road to the thesis. For convenience in discussing the steps along the way, I am dividing the process arbitrarily into seven hurdles. Activities on each section of the route will overlap with those in the previous or next section. For example, you may be searching the literature, writing the proposal, and beginning the research all during the same period, but it is helpful to have some of the literature search and methods of the proposal done before you begin the research.

A6.1 HURDLE 1

For your satisfaction and success, the first steps along the road must produce an inviting but practical plan. You should choose a topic for research and an advisor whom you can believe in and work with intensively for at least 2 years. You will probably investigate the graduate school you want to attend, study which areas of research are prominent in the department in which you wish to enroll, and find out as much as you can about major professors working in your area. Read some of the publications by prospective advisors, and then communicate with them, go through the admissions process, and select or accept a specific advisor.

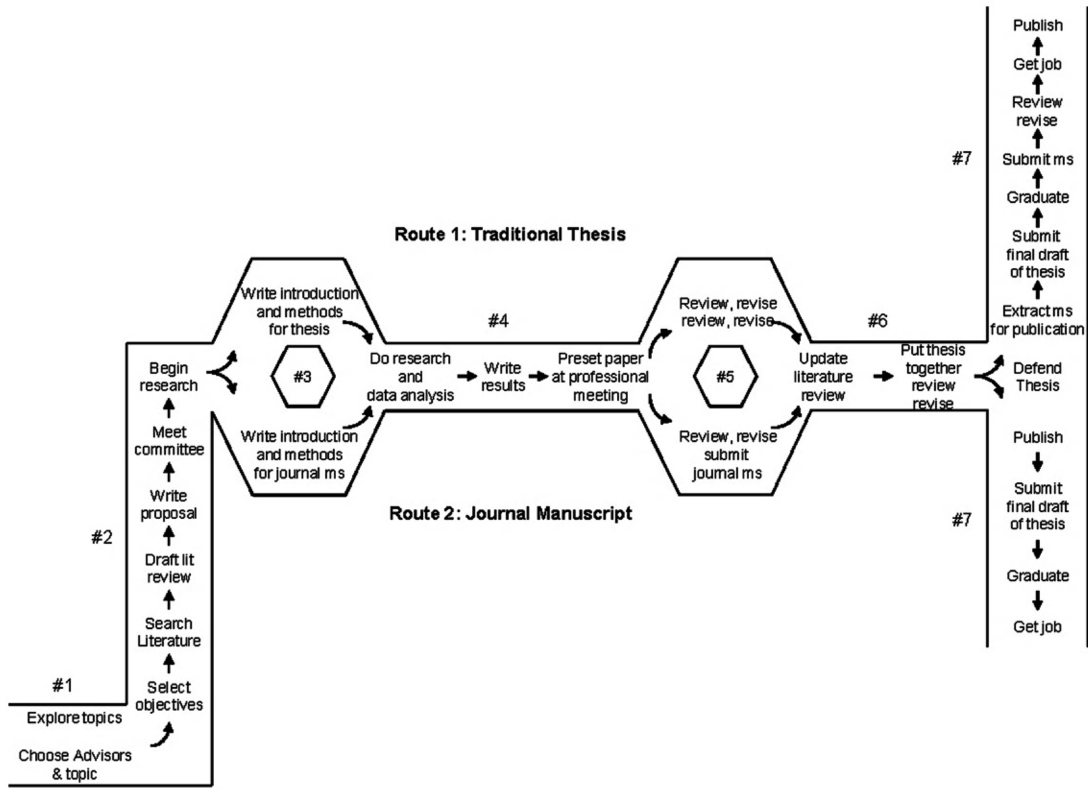


FIGURE A6.1 Alternate routes on the way to a thesis and graduation.

Through library searches, you should explore topics that are related to the work of the professor with whom you will work, and when you meet with him or her, have some ideas in mind about what the research project you want to pursue will entail. With your advisor's help, then, you will consider possible hypotheses and select specific objectives for your research. At this point, having read some literature on the subject will be a real help. On the basis of what your subject involves and with the help of your advisor, choose graduate committee members and visit with each of them about your plans. Now you are ready to go to work.

A6.2 HURDLE 2

With your objectives in mind, search the literature and write a draft of your literature review. This review will be updated toward the end of your program, probably to be used as a chapter of your thesis. With that rough draft behind you, write a draft of your proposal, review it, revise it, give it to your major professor for review, and revise again. Your advisor may ask that you do some preliminary experimentation before your proposal is ready for committee. When he or she approves, submit the proposal to your graduate committee and meet with them to discuss your program. You will probably be taking courses during this time. Six months or more may have passed by now. (It will be a year or more if you do not move quickly but meticulously over these first two hurdles.)

A6.3 HURDLE 3

Except for classes, research will take most of your waking hours for the next year. But do not make your last year more difficult or extend the time for your program by failing to write along the way. As you begin the research, you should choose which thesis path you will take, and at this point the routes divide somewhat. See Chapter 6 for further information on thesis formats. The traditional route means your thesis will ultimately consist of an introduction and chapters on literature review, methods, results, and discussion. You may have other addenda, such as appendices and an abstract. This traditional thesis, as written, is seldom ready to publish when it is completed, but representative ideas and data can be extracted for publication later. The journal manuscript format means you write with publication in mind from the beginning, and a literature review chapter and other addenda will hold everything except the representative publishable material. To jump this third hurdle then, you need to write an introduction and a methods chapter for the traditional thesis or an introduction and methods section for the journal manuscript.

A6.4 HURDLE 4

The research and especially the analysis of data continue, and as they near completion, you write a draft of the results. You are probably at least a year

and a half into your program. With these results written, you are ready to attend a professional meeting and make a poster or slide presentation. It is time to think about prospective employers and to start making your reputation public. Investigate job offerings and network with possible employers while you are at the meeting, but do not think of going to work until the thesis is finished. Continue to review and revise the various sections of the thesis. If you are writing a publishable journal article as a part of your thesis, it should by now be reviewed in-house and ready to submit to the journal.

A6.5 HURDLE 5

Now get serious about finishing the thesis. For either format, supply the appendices, the abstract, and any other addenda you need. Update the literature review that your wrote more than a year ago. Review and revise each section repeatedly, without and with advice from your major professor. Put the thesis together. Review and revise again. It is not unusual to review and revise your thesis six or more times.

A6.6 HURDLE 6

The paths for the two thesis plans part again at this point. You are over hurdle 6 when you are ready to defend your thesis. Be alert to possible job openings.

If you are on the journal manuscript route, your manuscript should be in in-house or journal review or back to you and ready for subsequent revisions and publication. Be sure that complementary chapters or appendices of your thesis include all the data from your project that are not appropriate for your publication. If you have written a traditional thesis, you should extract representative data, write a journal manuscript, and ask for in-house reviews. Getting a draft of the manuscript ready at this point will make life less miserable as you are seeking employment and beginning a new job. Note that although the road behind you may have been smoother or simpler than that for your colleague who was writing the journal manuscript all along, once you submit the final draft of the thesis to committee, hurdle 7 may be somewhat more difficult to scale with the publication still to be submitted, reviewed, and revised.

A6.7 HURDLE 7

Reviewing, revising, publishing, defending the thesis, taking exams, presenting a departmental seminar, and applying and interviewing for a job may all confront you at once. But over this final hurdle lie your three ultimate goals: your degree, a publication, and a job or a new degree program. The order in which the goals are accomplished can depend on your priorities and on which route you took to this point. You are probably thinking about employment and

may want to apply and interview by the end of hurdle 6 or now, but finish this thesis before you go to work, if possible. The publication may be behind you if you took the journal article route; at least it should be to journal review. As you approach graduation, establish priorities carefully. The job you want may become available before you finish the thesis. Do not sacrifice the degree prematurely for new short-term goals. The completed degree and a publication can be important stepping stones to your long-range plans. Remember that it is difficult to finish the thesis and produce a publication while you are becoming oriented to a new job. If you are going on for another degree, you may find that completing the thesis and a publication can interfere with scaling hurdle 1 again. Plan your strategy carefully and make a smooth jump over hurdle 7 so that reaching your final goals is a satisfying benchmark in your career.

Appendix 7

Sample Review of Manuscript Submitted for Publication

The following is a review by Dr. Gail Vander Stoep of Michigan State University that was done for a journal editor on a manuscript submitted for publication (used with permission from Dr. Vander Stoep). It has been abridged for inclusion in this appendix. The marginal notes are mine. Note how thorough and organized the review is, with comments on both general areas of content and organization as well as specific points. The reviewer accompanied these remarks with a copy of the manuscript marked clearly with even more specific details that needed to be addressed in the revision. Throughout, there is a tone of concern for the quality of the paper and a recognition of its value. Although this version of the paper was weak, note the positive comments made and the reviewer's ability to criticize and evaluate without being disparaging. The criticism is compelling but is always accompanied by suggestions for amending weaknesses. The authors of the paper expressed sincere appreciation for this review, and by incorporating the suggestions, they produced a good paper, which was subsequently revised twice and then published.

University-Based Education and Training Programs in Ecotourism or Nature-Based Tourism in the USA
for
Journal of Natural Resources and Life Sciences Education

GENERAL REVIEW, RELEVANCE, AND RECOMMENDATION

Reviewer begins with positive comments.

It appears that the content of the article fits within the scope of the journal content. Issues of resource preservation, conservation, resource use and management, and tourism are not new, but consideration of all of these issues certainly is gaining wider attention across many sectors. University-based education that facilitates systems-based resource

Conscious of the audience of the journal.

analysis, planning, and management is critical. I would support publication of this article. However, I recommend revisions to clarify, focus, and tighten the paper, as well as to make it more relevant to JNRLSE readers.

Improving Relevance for Readers

General opinions on content.

—Somewhere in the introductory and/or historical perspectives sections, indicate (briefly) how ecotourism/nature-based tourism may have implications for various "natural resource" segments (e.g., natural and archaeological resources and links to agriculture-based tourism).
—Expand the "conclusions and recommendations" section, including discussion of relevance to readers, future curriculum development or revision, and the possible need for continuing education.

Title

Specific suggestion with support for her opinion.

Consider removing "and Training Programs" from the title because it appears that the scope of this study is education-based and describes individual courses.

General Editorial Comments

Reviewer is flexible and concedes that she may not have all the best answers.

I am returning my copy of the paper with rather extensive comments written directly on the manuscript. Many of the notations are strictly editorial and deal with punctuation, capitalization, syntax, grammar, simplification of sentences, or authors may develop something even better or more in line with their thoughts.

Introduction

Another positive statement.

I like the introduction as a way to introduce the concept of and need for incorporating ecotourism concepts into university curricula. The introduction also needs to clearly define the need or rationale for the study and its results. WHY do we need to know about ecotourism/nature-based tourism curricula? Clarify why it's a problem that no data are available. (As stated, it's simply "unfortunate," as viewed by the authors.)

Historical Perspective

I believe the historical perspective section is pertinent to the paper, particularly in defining the terms ecotourism and nature-based tourism. However, the discussion could be expanded to address issues of … [Reviewer goes into detail here on issues that should be addressed].

Reviewer clearly rejects this discussion but has positive suggestions for its use in another publication.

I would delete the entire discussion (and Table 1) about ROS and a potential parallel with a TOS. The ideas and linkages are not fully developed; there are some "challengeable" holes in the descriptions … [Reviewer gives specific examples]. There is not enough space in this article to fully and logically develop the concept. (Perhaps the

idea could be more fully developed for another paper for a different outlet.)

Makes a point on unity and organization.

Page 4, starting with line 19: This section seems to be more appropriate as part of the "methods" section than "historical perspective."

Research Methods

Reviewer presents ideas in the form of questions and leaves to the authors the responsibility for determining whether and how to answer them.

Perhaps a little more development of the methods section would be helpful. Some questions I had:
—Any overlap in listing of specific programs/departments among the three lists?
—What types of questions were included in the one-page questionnaire?
—How was content analysis done?
[The reviewer continues with a dozen other questions.]

Results

Points out the need to clarify the meaning of results.

Before beginning discussion of actual results, clearly present the response rate versus those responding who OFFER or PLAN TO OFFER a course with ecotourism content. Page 5, lines 16–19 are confusing.
Comment (Page 5, lines 21–22) seems to be more of a conclusion than result.

And the need for details.

Throughout the "results," clarify what the percentages are based upon; e.g., total number of returned questionnaires, total number of schools reporting current and/or future offering of courses, total number of schools currently offering ….

Reviewer points to specific parts of the paper and, without revising, helps to direct the logical thinking needed to revise.

A couple of logic concerns:
—Page 8, lines 16–18 (see comment on MS); need transition or link to the list of "other common objectives."
—Page 9, lines 8–11, and Figure 5: There seem to be different ways of interpreting "the primary focus" … actually as "the primary focus" versus simply "a component of." This is confusing.

Points to specific details that could mislead a reader.

Your use of the word "classes" is confusing. Does "class" refer to the four categories or classifications of approaches to instruction or to courses? It may be that the word is used interchangeably.

Positive comment and indirect suggestions for the authors to consider.

The descriptions of the four general approaches to instruction are helpful and interesting (and necessary). However, this section could be strengthened by describing HOW the four approaches were determined (perhaps this is more appropriate for the methods section?) and by indicating the number or percentages of courses in this study that use each of the approaches.

Conclusions and Recommendations

This section was deservedly the most criticized part of the paper by all reviewers. This reviewer is direct

This section is the weakest part of the paper. Most of the elements currently included in the section would seem more appropriate elsewhere:
—Limitation of scope and diversity: methods section. (However, a recommendation for future research and inventory is appropriate here.)

but has prefaced condemnation of this part with earlier positive comments about the paper's value. She follows her direct remarks with constructive criticism on how to improve the conclusions.

—Comments about the Ecotourism Society seem more appropriate as a sidebar or footnote.

Beginning on line 3, Page 13: It is not clear how results of the study indicate a need to improve information exchange. This may be a recommendation of the authors but is not directly linked to the results as presented.

This section could be strengthened by expanding the conclusions, adding discussion of implications for ecotourism education/training/industry, and by providing specific recommendations. Explain WHY information exchange is important.

Figures and Tables

Reviewer brings up an important point of encroaching on the editor's territory.

I suspect that some of the figures may not reproduce well, especially if reduced to one-column size. (I defer to the editors for this.)

Style guidelines for format (including capitalization) should be checked, then used consistently.

Deals with clarity and content in the tables and figures.

Discrepancies exist between results in Figure 2 and the "Year" column of Table 2. (Is Figure 2 needed?)

Figure 4: What were criteria for …

Other comments and questions are written directly on the manuscript.

Double check consistency of information and assumptions between tables/figures and narrative within the manuscript.

A final candid, direct opinion on the value of the paper.

I recommend that the manuscript be revised with particular attention to clarifying the manuscript and developing a strong "implications" or "relevance" component. It could then be appropriate for publication.

Appendix 8

Evolution of a Title

Suppose that the following six titles are meant to describe the same study. Some are better than others, and none may be fitting for a specific manuscript. Your choice will depend on which words are most important and which best describe the study involved. Think in terms of the words and the arrangement of words that will lead a reader to the central points in your study. The publisher may also have certain criteria for titles, such as length and the use of scientific names.

Sample Titles:

1. Controlling the Bollworm
2. Investigations into the Effects of Several Selected Phenolic Acid Compounds on the Mortality Rate, Developmental Time, and Pupal Weight Gain of the Cotton (*Gossipium hirsutum* L.) Bollworm (*Helicoverpa zea* Boddie) in Studies Involving Larvae Fed a Synthetic Diet in the Laboratory
3. The Effects of Selected Phenolic Compounds on the Mortality, Developmental Time, and Pupal Weight of *Helicoverpa zea* Boddie: Synthetic Diet Studies
4. Benzoic and Cinnamic Acids in Synthetic Diets Retard Development of *Helicoverpa zea* Larvae
5. Influence of Benzoic and Cinnamic Acids on Mortality or Growth of Bollworm Larvae
6. *Helicoverpa zea* Larvae Response to Benzoic and Cinnamic Acids

Number 1 might serve as a headline for an article in a newsletter for cotton producers, but it contains too little information to describe a scientific study.

Number 2 is too long, and the inclusion of all these words cannot be justified. Certainly the first three and the last three words can be omitted. Then why not "selected" rather than "several selected"? Why not "phenolic acids" rather than "phenolic acid compounds"? Why not "mortality" rather than "mortality rate"? Why not "pupal weight" rather than "pupal weight gain"? And can't we simply say "bollworm larvae" instead of "bollworm in studies involving larvae"? There is probably no need for the scientific name for cotton because we

are naming the cotton bollworm and not the cotton plant. Whether the scientific name *Helicoverpa zea* Boddie appears in a title will depend on the style of the publisher. The authority Boddie might be omitted. Or the scientific names might be used and the common name cotton bollworm might be omitted. These choices would be based on the style of the publisher and the importance of the words for the audience.

Number 3 is also rather long. We might omit "The effects of" and "the" before "mortality," but we still have a long title and must make some other choices. Can we save "synthetic diet studies" for the abstract? Some publishers avoid two-part titles with the colon. Can we say "development" rather than "developmental time"? Or can we combine the words "developmental time and pupal weight" into a simple term such as "growth"? Again, answers to these questions depend on what we need to best describe the study and which key words will allow the readers to retrieve a publication relevant to their interests.

Number 4 is perhaps short enough but could still be improved with the omission of "in synthetic diets," unless that information is vital to a brief description of the study. This title adds a detail by naming the specific phenolics used. This information may be worth the extra space needed. However, the title breaks a convention in scientific writing by using an active verb, "retards," that describes the outcome of the study. Characteristically, popular press uses such verbs in headlines, but the scientific report simply describes results of a research effort and discusses outcomes but allows the reader to decide on any final conclusion that can be drawn from the work. What happens under the controlled conditions of a given experiment may not constitute a universal truth, and the active verb appears to be proclaiming such a truth. Some scientific periodicals use active verbs in titles, but check your own journal before you submit a title with an active verb.

Number 5 is approximately the same length as and is similar to number 4 except it avoids the active verb and uses the common name of the species rather than the scientific name. The choice of name would depend on which one you and your publisher believe will best communicate the information with your audience. The use of "mortality or growth" is somewhat more specific than is "development" in number 4 and may be worthy of the extra two words, especially if we can delete "in synthetic diets."

Number 6 is less descriptive of the paper's content but conserves words. Here, I reserve the mortality and growth for the abstract and generalize with the word "Response." Such a title may be the best choice, especially for display on a poster or slide.

Appendix 9

Evolution of an Abstract

The following abstract is based on studies done in the laboratory of Dr. Justin R. Morris at the University of Arkansas and is used with his permission. An original abstract from that research has been altered and lengthened with fictitious ideas and data and then pared to acceptable lengths. The examples show four versions of the same information. Notice changes in organization, content, and wording between the drafts. Little content is lost with a reduction from approximately 370 words to 280 words and then to approximately 215 words in a third version. When I submit this third version with the manuscript to a journal, the editor may inform me that the abstract must be cut to no more than 150 words. To satisfy this request, I have to get rid of the full justification and conclusion and reduce methods and results to a bare minimum. The fourth version with approximately 140 words has lost some content but not the objectives, the most important methods, and the results. The third or fourth version might be the one published, depending on the editor's preference.

WORKING ABSTRACT 1 (373 WORDS)

Evaluation of Winegrapes for Suitability in Juice Production

Indirect statement of objective.

Materials.

Rationale or justification for the study.

Methods.

Note the wordiness and repetition throughout, as in "stored at 37°C" and "storage at 37°C."

Abstract. A series of chemical and sensory analyses was designed to determine which, if any, of 10 winegrapes grown in 1994 in Arkansas were suitable for nonalcoholic grape juice production. Five of the 10 were classified as red grapes: Chancellor, Cabernet Sauvignon, Villard Noir, Cynthiana, and Noble. Five were classified as white grapes: Aurore, Cayuga, Chardonnay, Vidal, and Verdelet. The traditional juice grapes Niagara and Concord were used as controls for comparisons in the study. Sensory quality and consumer acceptability of grape juices depend to a great extent on the process by which the juice is produced but also on the cultivar or blend of cultivars used. With today's processing techniques, winegrape cultivars may also produce nonalcoholic juices acceptable to consumers' tastes. Four different means of juice production were used to process the grapes: immediate press, heat process (60°C), heat process (80°C), and 24-h skin contact after pressing. Processed juices were sealed in 0.8-liter bottles and stored at 37°C. The juices were evaluated 1 month after processing and again

	after 5 months' storage at 37°C. Chemical and sensory analyses were
Results.	run. Chemical analysis showed that red grapes had more acidity than did white grapes, but white grapes, except for Cayuga, had more soluble solids. Soluble solid-to-acid ratios were highest in the red grapes Noble and Cynthiana and lowest in the white Chardonnay and Vidal. Other cultivars showed no significant difference in soluble solid-to-acid ratios. Chemical analysis showed no difference within cultivar for the treatment process, except that in 6 of the 10 cultivars, the 24-h skin contact produced more soluble solids. Consumers' preference, as
Also wordy.	represented by a sensory panel, for flavor of juices revealed greater preference for nonheat treatments, whereas the heat treatments were more preferred in color evaluations. Flavor was considered to be the most important attribute to the consumer; panelists tended to prefer those juices that had relatively higher soluble solids-to-acid ratios. The most preferred white grape juices were the immediate press of Niagara and Aurore and the 24-h skin contact treatment of Niagara, Verdelet,
No overall conclusion.	and Vidal. Rank preference for flavor of red grape juices did not indicate a significant preference among cultivars, thus suggesting all red winegrape cultivars were equally suited for varietal juice production.

WORKING ABSTRACT 2 (280 WORDS)

Title Shortened.	**Suitability of Winegrapes for Juice Production**
Rationale shorter and moved to the beginning.	**Abstract.** Recently developed processing methods may provide nonalcoholic juices from winegrape cultivars that are acceptable to con-
Direct statement of objective.	sumers. Our objective was to test 10 winegrape cultivars and four juice processes to determine their suitability for juice production.
Materials.	The five red grapes (Chancellor, Cabernet Sauvignon, Villard Noir, Cynthiana, and Noble) and five white cultivars (Aurore, Cayuga, Chardonnay, Vidal, and Verdelet) were compared with traditional
Methods.	juice cultivars Niagara (white) and Concord (red). Juices from four processes—immediate press, heat process (60°C), heat process (80°C), and 24-h skin contact after pressing—were sealed in 0.8-liter bottles and stored at 37°C. They were evaluated at 1 month and 5 months after processing. Chemical analysis showed that red grapes had more acidity, but white grapes, except for Cayuga, had more solu-
Results.	ble solids. Soluble solid-to-acid ratios were highest in the red grapes Noble and Cynthiana and lowest in the white Chardonnay and Vidal. Other cultivars showed no significant difference in soluble solid-to-
Less wordiness here than in the first version. Most sentences have been shortened, but content is not lost.	acid ratios. Chemical analysis showed no difference within cultivar for the treatment processes, except that in 6 of the 10 cultivars the 24-h skin contact produced more soluble solids. A sensory panel preferred flavor of juices from nonheat treatments but ranked color best in the heat treatments. Flavor, the most important attribute for consumers, was rated highest in juices that had relatively higher soluble solids-to-acid ratios. The most preferred white grape juices were the immediate press of Niagara and Aurore and the 24-h skin contact
Overall conclusion.	treatment of Niagara, Verdelet, and Vidal. Rank preference for flavor of red grape juices did not indicate a significant preference among cultivars. Most of these winegrapes may be as suitable as juice grapes for nonalcoholic juice production.

ABSTRACT, VERSION 3 (215 WORDS)

Suitability of Winegrapes for Juice Production

Rationale shortened even more.
Objective.
Materials.
Methods.
Results.
Notice that wording is still more concise than in version 2, but little or no content is lost.
A more specific conclusion.

Abstract. Recent processing methods may provide acceptable nonalcoholic juices from winegrapes. To determine acceptability of the juices, we compared five red (Chancellor, Cabernet Sauvignon, Villard Noir, Cynthiana, and Noble) and five white (Aurore, Cayuga, Chardonnay, Vidal, and Verdelet) winegrapes with traditional juice cultivars Concord (red) and Niagara (white). Juices processed by immediate press, heat process (60°C), heat process (80°C), and 24-h skin contact after pressing were sealed in 0.8-liter bottles and evaluated after 1-month and 5-month storage at 37°C. Chemical analyses showed more acidity in red juices but more soluble solids (SS) from white grapes except Cayuga. The SS/acid ratios were highest from red grapes Noble and Cynthiana and lowest for white Chardonnay and Vidal, with no significant differences in other cultivars. Processes produced no differences within cultivar except the 24-h skin contact produced more SS from six cultivars. A sensory panel ranked color best in the heat treatments but preferred flavor of juices from nonheat treatments. Juices with relatively higher SS/acid ratios rated highest for flavor. Acceptable white grape juices were from the immediate press of Niagara and Aurore and the 24-hr skin contact treatment of Niagara, Verdelet, and Vidal. Panelists indicated acceptance but no flavor preference among red juices. All red winegrapes tested and Aurore, Verdelet, and Vidal white winegrapes appeared suitable for juice production.

ABSTRACT, VERSION 4 (140 WORDS)

Suitability of Winegrapes for Juice Production

No rationale.
Objectives and materials combined; specific details are gone.
Basic methods still clear.
Results—Here we lose some details contained in version 3, but the most notable results are preserved.
No conclusion.

Abstract. Five red and five white winegrape cultivars were compared with traditional juice grapes Concord and Niagara to determine acceptability of juices. Juices processed by immediate press, heat process (60°C), heat process (80°C), and 24-h skin contact were sealed in 0.8-liter bottles and evaluated after 1- and 5-month storage at 37°C. Red juices had more acidity, but white grapes, except Cayuga, produced more soluble solids (SS). The SS/acid ratios were highest from red grapes Noble and Cynthiana and lowest for white Chardonnay and Vidal. A sensory panel preferred color from heat treatments but flavor of juices from nonheat treatments. Juices with high SS/acid ratios rated highest for flavor. White grape juices were acceptable from immediate press of Niagara and Aurore and 24-h skin contact treatment of Niagara, Verdelet, and Vidal. Panelists indicated acceptance but no flavor preference among red juices.

Appendix 10

Putting Data into Tables and Figures

TABLES

Two versions of the same information appear in Tables A10.1a and Table A10.1b. Notice how Table A10.1b has refined the information for more clarity and ease in reading.

The arrangement in Table A10.1a does not allow us to read down from the headings to the information in the stub and field. Reps, or replications, listed in the stub are not germination as their heading states, numbers in the field are not treatments but germination, and the reader is not told that the numbers

TABLE A10.1a **Percentage Germination of *Phytolacca americana* Seeds with Hot Water and Sulfuric Acid Treatments**

	None	Treatments			
Germination		Hot Water		Sulfuric Acid	
2001		90 min/80°C	12 h/60°C	15 min	30 min
Rep 1	2	19	30	76	49
Rep 2	0	23	30	54	41
Avg. 2 reps	2	21	30	65	45
2002					
Rep 1	3	42	36	80	42
Rep 2	5	28	32	62	76
Avg. 2 reps	4	35	34	71	59
*Mean (both yr)	3	28c	32c	68a	52b

**Means followed by the same letter are not significantly different at the 0.05 level.*

TABLE A10.1b Percentage Germination of *Phytolacca americana* Seeds Treated with Hot Water and Sulfuric Acid

Treatment (time/temp.)	Germination (%)		
	2001	**2002**	**Mean***
Control	2	4	3d
Hot Water (h/°C)			
1.5/80	21	35	28c
12.0/60	30	34	32c
Sulfuric Acid (h)			
0.25	65	71	68a
0.50	45	59	52b

**Means followed by the same letter are not significantly different at 0.05 level.*

in the field are percentages. The 2001 should appear parallel to 2002 and not as part of the main stub head above the line. Notice that the treatment times appear as mixed units of minutes and hours. In addition to these points that cloud the clarity in presentation, too many data points may distract from the point made in the table. Representative data would be better than all of them. The analysis has not been done between replications but on combined replications and years. Comparison of the means is likely all that is needed.

Table A10.1b improves the clarity of information by making the table read down, combining the replications as was done in the statistical analysis, using uniform units for measuring time (h), and providing meaning to the numbers in the field with the percentage sign (%). Depending on the importance of this information to the study and space available in the paper, we might use Table A10.1b in a publication, or we might simply provide the mean percentages and a comment on significant differences in the text without using a table at all.

FIGURES

Figures A10.1a and A10.1b depict the same fictitious data. In Figure A10.1a, three of the lines, those for the poultry manures, are not statistically different. The symbols for all six lines in Figure A10.1a are black circles, squares, and triangles, and their use with the poultry manure data does not help much in distinguishing one line from another.

The lines themselves should be the most prominent images, but the line around the box is heavier and distracting. The entire figure is compressed

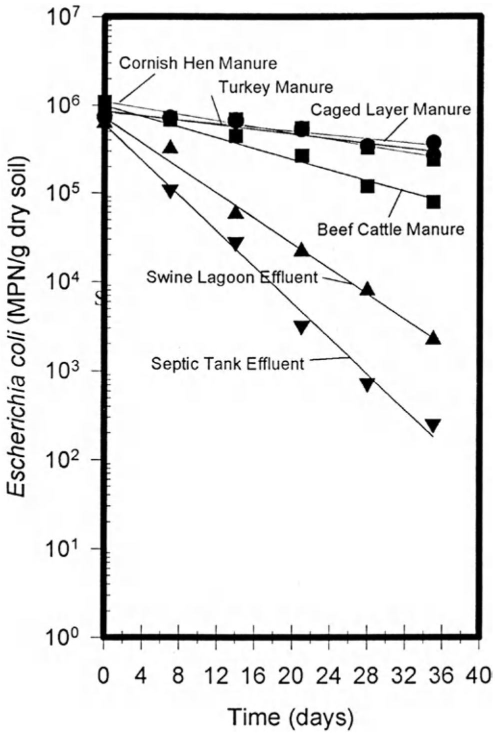


FIGURE A10.1a *Escherichia coli* die-off in a Captina silt loam amended with Cornish hen manure, turkey manure, caged layer manure, beef cattle manure, swine lagoon effluent, or septic tank effluent.

vertically so that the intervals on the *x*-axis are unconventionally shorter than those on the *y*-axis. The words *Time* and *days* are somewhat redundant, and *Days* alone would be sufficient. The tic marks should not extend both within and outside the axis lines. The *x*-axis also contains too many numbers that run together, and they do not represent the actual days on which the data points fall. That axis should not be extended beyond the last data point. Space is also wasted in the area between 10^0 and 10^2 on the *y*-axis, and because the axis is on a logarithmic scale, it need not begin at zero. Statistically, the fit of the lines with data is not apparent.

Notice the improvements in Figure A10.1b. The data for all three kinds of poultry manure have been combined. In the text, I will tell my audience what kinds I used and that no significant difference in die-off of *E. coli* occurred among the three. I will make clear that the R^2 represents the fit of the regression line of the geometric means for the three poultry manures. Revisions in

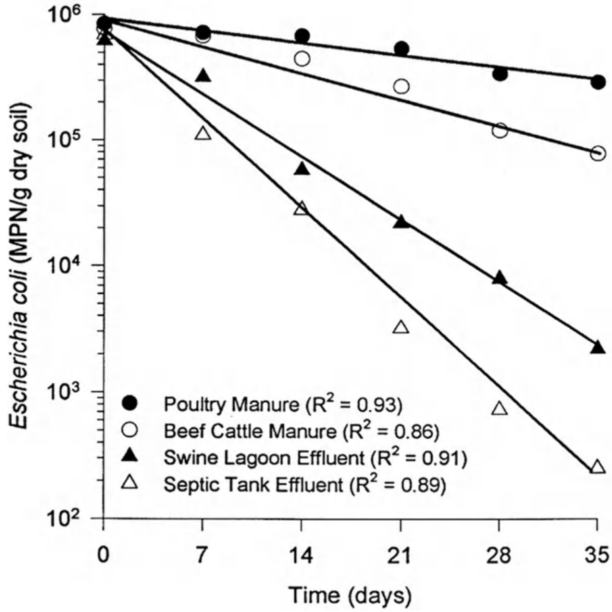


FIGURE A10.1b *Escherichia coli* die-off in a Captina silt loam amended with poultry manure, beef cattle manure, swine lagoon effluent, or septic tank effluent.

the lines, symbols, and axes of Figure A10.1b to achieve greater simplicity make the message conveyed by the data easier to comprehend. Increasing the length of the *x*-axis, removing the heavy box, and making tic marks more distinctive also add to clarity.

Appendix 11

Sample Letter Requesting Copyright Permission

The following is a copy of a letter requesting copyright permission for use of the review in Appendix 7 by Dr. Gail Vander Stoep. Even though Dr. Vander Stoep has no registered copyright on this review, it still belongs to her, and permission should be requested. Note that the letter tells her where and how the material will be used and includes a copy of the version that will be published. It also assures her that she will receive credit and acknowledgment for the work.

The letter itself provides a simple form that can confer the official permission once it is signed. If my request were for a number of sections in a work or required lengthy description, I would devise a form to list information on materials requested. For the author's files, a duplicate of the request with an original signature by the person making the request is enclosed.

Department of Agronomy
University of Arkansas
Fayetteville, AR 72701
13 May 1996

Dr. Gail Vander Stoep
Michigan State University, PRR Department
131 Natural Resources Building
East Lansing, MI 48824-122

Dear Dr. Vander Stoep:

I am preparing a handbook, entitled *Scientific Papers and Presentations*, to be published by Academic Press, Inc., San Diego, California, in 1996. The book will be used by graduate students in the sciences and by career scientists. To illustrate points that I make in the text, I plan to use several appendices. I want one of these to be the review you did for the *Journal of Natural Resources and Life Sciences Education* on the manuscript entitled "University-Based Education and Training Programs in Ecotourism or Nature-Based Tourism in the USA."

Can you please grant me permission to reproduce an abridged version of your review in this book and in any subsequent editions or reprints thereof. I enclose a copy of the version I want to publish.

With my use of the review, full credit and acknowledgment will be accorded to you. Please confirm your permission for me to use this material by completing the form below and returning this sheet to me. I enclose a duplicate for your files.

Sincerely,

Martha Davis

Permission is granted for use of the materials described in the letter above.

Date ________________ Signature __________________________

Title ______________________________

Appendix 12

Use of Color in Visual Aids

The following excerpt is taken from Chapter 4, "The Theory of Colors," in *Cartographic Relief Presentation* by Eduard Imhof. (Permission to use this material has been granted by Walter de Gruyter, Hawthorne, NY.) I certainly recommend that anyone interested in the use of color consult Imhof's book. Imhof's expertise is in the area of cartography, but what he says about color can apply equally to its use in any visual presentation. In reading the following, you may substitute the term **visual aid** for **map** and think of these principles and rules in regard to making slides, a poster, or other colored displays. Notice the emphasis on the following points:

- Subdued colors, neutral colors, or those toned down with gray are best for backgrounds and large areas.
- Bright colors and contrasting colors are best reserved for highlighting points of emphasis or for small areas.
- Combinations and juxtaposition of colors require that the choices be complementary and harmonious.
- Individual choices allow the creator of the map (visual aid) to articulate his or her point of emphasis and make the communication effort unique.

IMHOF'S THEORY OF COLORS

On the Harmony of Colors and Their Compositions

The eagle has a keener eye than man, but all that he derives from his perceived image is whether or not it is of interest to him, perhaps edible or dangerous. The human being, although, as a rule, more highly developed in an intellectual–spiritual sense, views the visually perceived world—the forms and colors of things—primarily as a psychological experience. He hangs a colored picture of red roses above his bed. But when the same colors appear in the picture of an open wound, he is horrified.

A color in itself is neither beautiful nor ugly. It exists only in connection with the object or sense to which it belongs and only in interplay with its environment. Concepts of harmony, accord, and melody always refer to

composition—that is, to the way in which they harmonize or interplay with acoustics or visual elements. With a finely developed artistic sense or as a result of careful education, we can, of course, learn to perceive even non-objective, abstract color compositions as beautiful or ugly. Many simple heraldic figures are, for example, included in such abstract compositions.

Attempts have often been made, and are still being enthusiastically made today, to evaluate drawing and painting by scientific methods. This, however, is very difficult. Here one cannot expect to find laws which can be proven but, rather, demonstrations of generally valid perceptions, experiences, and fashions.

It has been shown repeatedly that great artists have broken through the accepted laws of composition and, in so doing, have achieved extraordinary effects. In the field of painting, intuitive, artistic perception takes over where scientific logic fails.

In spite of these reservations, there follows here an attempt to set down several *general rules of color composition*, insofar as they are significant for maps.

First to be examined are the *combinations of two or more colors*, taken outside the context of pictures or compositions. The latter will follow later.

a) Combinations of two or more colors. Which colors, for example, if presented as adjacent, but separate, similar rectangles or rectangle-like areas, would be most pleasing, and which would clash or be out of harmony? The answers to such questions, vary greatly as a rule from one case to another. Fashion, education, psychological inclination and the emotional state at the time are as important here as the existence of any artistic inclination.

In general, the unbroken sequence of colors from the color circle is perceived as harmonious. Compounds of only two colors have harmonious effects if they are complementary colors, that is, if they lie opposite each other in the color circle. The same principle holds for groups of three. Examples are:

Groups of two:
- Yellow–violet
- Yellow orange–blue violet
- Orange–blue
- Red orange–blue green
- Red–green
- Red violet–yellow green

Groups of three:
- Yellow–red–blue
- Yellow orange–red violet–blue green
- Orange–violet–green
- Red orange–blue violet–yellow green

Such duos and triads are even more harmonious if their colors are lightened by white, darkened by black or toned down to a pastel shade by grey, to equal extents. *Subdued colors are more pleasing than pure colors.*

Brown colors are composed of yellow and red, and a small amount of blue. Their harmonious complements are found in colors in which that tone is dominant which is weakest in the brown in question. Examples:

Yellowish brown–blue violet
Reddish brown–blue green

In general, experience has shown that harmony exists between two colors when their subtractive mixtures produce black or grey and, correspondingly, their additive mixtures produce white or grey. This holds true for every pair of complementary colors and, hence, for any two colors whose numerical values in the Hickethier color classification yield, together, a sum consisting of three equal digits.

Leonardo da Vinci said, "There is no effect in nature without cause." Therefore, one searches for explanations of the color harmonies described above. One could find them perhaps in an unconscious striving for order, in the complementary character of colors, or in their contrasts. Perhaps, however, the causes of harmonious effects lie deeper, perhaps in our familiarity with the colors of daylight. We perceive a color composition to be well integrated or harmonious when it results in the white of daylight if mixed additively, or produces grey when mixed subtractively. This applies for the groups listed above. As we have already established, two adjacent colors blend mutually as far as our sense of sight is concerned, and each color tends toward the complementary color of the neighboring hue. *Psychological color perception always tends, therefore, in the direction of composing complementary colors*. This statement appears to be quite significant in explaining the perception of harmony discussed here.

For the same reasons, perhaps, two or more different, bright colors—placed in close proximity to each other—have an unharmonious effect when their combination does not make up white, grey or black.

Examples of this type are the following groups of two:

Red and violet
Violet and blue
Blue and green
Strong yellow and pale whitish red

One of the most troublesome area colors, for cartographic and other purposes, is *yellow*. It can provide good effects, when it is used in carefully calculated amounts, to give a "warming" effect to *whole* areas as a base of background tone, but is poor in contrast with white or pale, desaturated bright, yellow-free areas. Yellow and white are similar in that they are the light components of various illumination sources. They stand out poorly when placed adjacent to one another. Midday light and twilight do not appear in a landscape simultaneously. On the other hand, however, yellow goes well with blue,

violet, and blue-brown probably because of the effects of contrast. Yellow light produces blue or violet shadows.

White, *grey* and *black*—as "*neutral*" colors, as a surfeit of or lack of daylight—go well with all the bright colors. The compatibility of white and yellow, described above, is the only exception. It is emphasized here once again that the clashing effects of other colors can be subdued by grey, black or dull brown intermediate tones. Unfortunately, however, in maps we can seldom make use of this facility.

So far we have dealt only with the colors themselves and have not gone into *area/size relationships in connection with colors* and into the various color intensities. The harmony of the colors can be considerably reduced, or even improved, if their *areas are unequal in size* and if the colors are of unequal intensity. *Relationships exist between color intensities and area dimensions*. The purer and richer a color, the smaller its area should be. The duller, the paler, the greyer, the more neutral the color, the larger the area which can be covered. Two bright colors in areas of unequal size go well together only when the smaller area component is strongly colored and the large area is weakly colored. Not only are the qualities of the individual components important, but their quantities as well.

Of a completely different type and based on other phenomena and conventions is a second group of color combinations with harmonious effects. It consists of the *sequence or the change of several continuously graduated colors of one and the same hue* [sic] gradation sequences such as these are brought about by the successive addition of white, grey or black—or even of another bright color …. These admixtures give desaturated series, pastel series, shaded series. In nature, they frequently result from differences in distances of observation, or in light intensities, or through atmospheric haze. We perceive them as pleasing or harmonious, perhaps because they have an ordering, grouping, connecting, calming effect and to a large extent reflect the environmental appearances to which we are accustomed.

b) Color compositions. "Tones, harmonies, chords, are not yet music" (Windisch). Only the composition as a whole determines the good and bad of a piece of graphic work. This is also true of a map. Here, of course, one is not completely free to create graphic form. Nevertheless, the cartographer should not blame the chains that bind him for any lack of taste in his work, because he also has sufficient alternatives available to allow his good aesthetic judgment to be employed.

There follow several empirical rules which are especially applicable to map design.

First rule: Pure, bright or very strong colors have loud, unbearable effects when they stand unrelieved over large areas adjacent to each other, but extraordinary effects can be achieved when they are used sparingly on or between dull background tones. "Noise is not music. Only a piano allows a crescendo and then a forte, and only on a quiet background can a colorful theme be constructed" (Windisch).

The organization of the earth's surface facilitates graphic solutions of this type in maps. Extremes of any type—highest land zones and deepest sea troughs, temperature maxima and minima, etc.—generally enclose small areas only. If one limits strong, heavy rich and solid colors to the small areas of extremes, then expressive and beautiful colored area patterns occur. If one gives all, especially large areas, glaring, rich colors, the pictures have brilliant, disordered, confusing and unpleasant effects.

Second rule: The placing of light, bright colors mixed with white next to each other usually produces unpleasant results, especially if the colors are used for large areas.

Third rule: Large area background or base-colors do their work most quietly, allowing the smaller, bright areas to stand out most vividly, if the former are muted, greyish or neutral. For this very good reason, grey is regarded in painting to be one of the prettiest, most important and most versatile of colors. Strongly muted colors, mixed with grey, provide the best background for the colored theme. This philosophy applies equally to map design.

Fourth rule: If a picture is composed of two or more large, enclosed areas in different colors, then the picture falls apart. Unity will be maintained, however, if the colors of one area are repeatedly intermingled in the other, if the colors are interwoven carpet-fashion throughout the other. The colors of the main theme should be scattered like islands in the background color (see Windisch, 318).

The complex nature of the earth's surface leads to enclosed colored areas, like these, all over maps. They are the islands in the sea, the lakes on continents, they are lowlands, highlands, etc., which often also appear in thematic maps, and provide the desirable amount of disaggregation, interpretation and reiteration within the image.

In this respect, great importance is laid on delineation of areas within maps on the selection of sections, and even on the combination of maps in atlases and also on map legends. Cleverly arranged, legends put life into empty spaces, loosen up uninteresting parts of the image and often produce a balance in the composition.

Fifth rule: The composition should maintain a uniform, basic color mood. The colors of the landscape are unified or harmonized by sunlight.

In many maps and atlases a special green printing color is used for low lying land apart from the blue of the seas. The impression produced is usually poor, the colors of the oceans separating sharply from those of the land areas. In the "Schweizerischer Mittelschulatlas" ("Swiss Secondary School Atlas") and in other maps, however, the low-land green is produced, by over-printing, from the light yellow (used to cover all land areas) and the blue of the oceans. Other mixed tones are also derived from a few basic colors. Only in this way can the unity of light and tone be introduced and disturbing color contrasts avoided.

The idea of a single, uniform basic color mood should not be exaggerated, however. The freshness of colors should not suffer and the contrast between

them should not be unduly subdued. The whole map sheet should not appear dull, jaundiced and dead.

Sixth rule: Closely akin to the requirement for a basic color mood, mentioned above, is that of a steady or gradual de-emphasis in colors. A continual softening of area tones is of primary importance in cartographic terrain representation. The natural continuity of the earth's surface demands a similar continuity in its image. Aerial perspective gradation helps this to be attained.

The principle is in no way opposed to a contrary requirement, that of contrast effects. A master reveals himself through the way in which he manipulates the different principles, using moderation on the one hand, but applying deliberate and carefully considered emphasis on the other.

In all questions of form and color composition, one should strive for simple, clear, bold and well-articulated expression. The important or extraordinary should be emphasized, the general and unimportant should be introduced lightly. Uninterrupted, noisy clamor impresses no one. Activity set against a background of subdued calm strength produces a deeply expressive melody.

This is also true in maps. The map is a graphic creation. Even when it is so highly conditioned by scientific purpose, it cannot escape graphic laws. In other fields, art and science may take different pathways. In the realms of cartography, however, they go hand-in-hand. A map will only be evaluated as good in the scientific and didactic sense when it sets forth simply and clearly what its maker wishes to express. A clear map is beautiful as a rule, an unclear map is ugly. Clarity and beauty are closely related concepts.

Appendix 13

Designing Slides and Slide Sets

The first principle for slide design is the same as that for any tool in scientific communication in science: *Be sure the message is clear.* Present the message as simply as possible for clear understanding based on the audience and the time they have for processing the information. Keep this principle in mind as you design each slide.

In support of this principle, the slides should be attractive and comfortable for viewing. What is attractive to you may not be attractive for most of your audience. For this reason, it is often best to observe the standards that are characteristic of good slide sets. The amount of information on each slide and the mix of slides with words, pictures, and data in tables and figures are usually basic features of the scientific slide set. Background design, color, spacing, and limited animation can help with both simplicity of the message and the attractiveness of the slide set.

Probably the most common problem with designing slides is overloading them with too many words or images. The following examples may help you to recognize how to limit the amount of material that the audience must view and digest as you are talking. In the first two examples, notice that the same basic information is presented. In Figure A13.1A, the words "Characteristics of" are superfluous and complete sentences are unnecessary. In Figure A13.1B, only

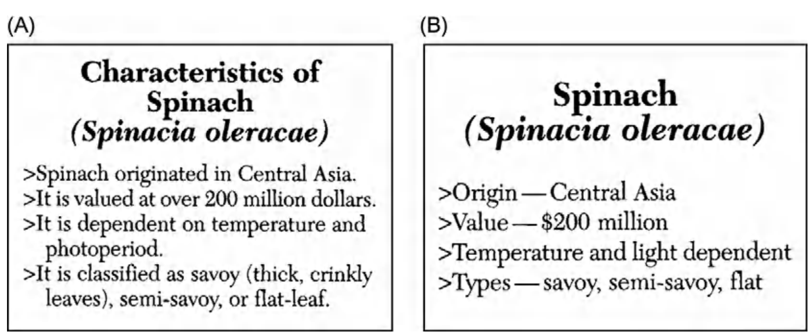


FIGURE A13.1

the key words are presented to represent the points the speaker wants to make. If the speaker assumes the responsibility for presenting the full sentences orally, the audience can better comprehend the key words and listen to the speaker at the same time. Figure A13.1A places a greater burden on the viewers in that they must read through the slide and select those points. Simplify each of your slides as much as possible.

A13.1 ANIMATION

Presenting complex details can sometimes be simplified with a flow chart, but too much information greets the audience at once if we simply present the entire image on one slide. Animation may be valuable in such a situation. In the following fours slides, feed the viewers the information gradually by building up to Figure A13.5, showing particular sections as you describe the content in them and then presenting the composite slide only after you have guided them through the information. I call this method the house-that-Jack-built technique of slide composition. Notice in Figures A13.3 and A13.4 the boxes for ammonium and nitrate are kept in the same locations as in Figure A13.2. The location and space are communicating, and we effectively break the convention of balance in this group of slides.

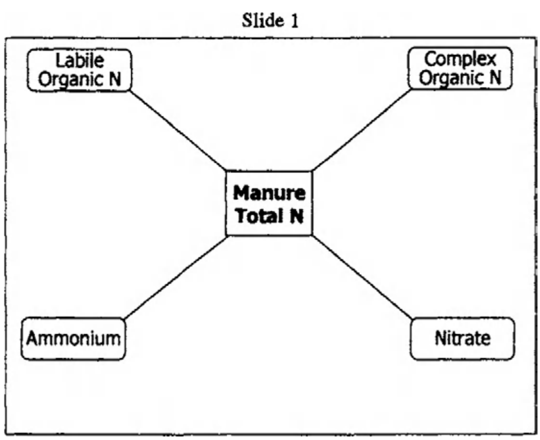


FIGURE A13.2

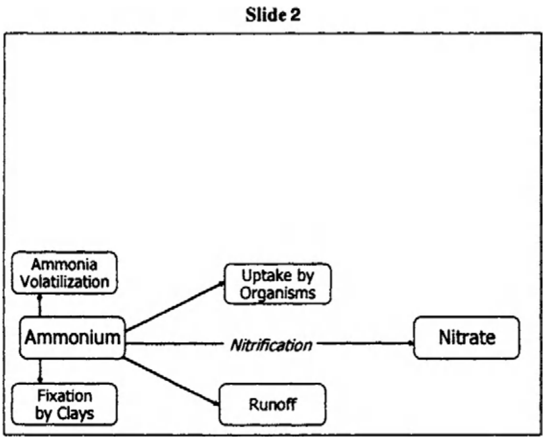


FIGURE A13.3

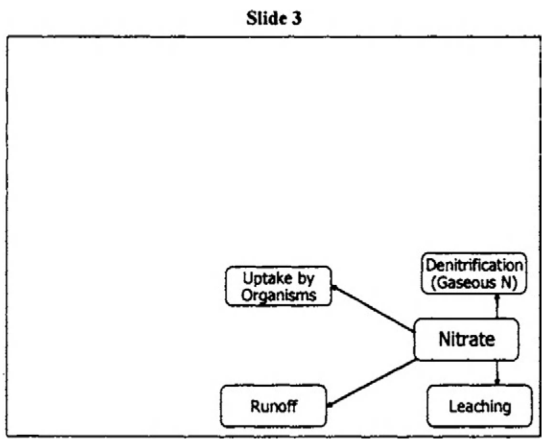


FIGURE A13.4

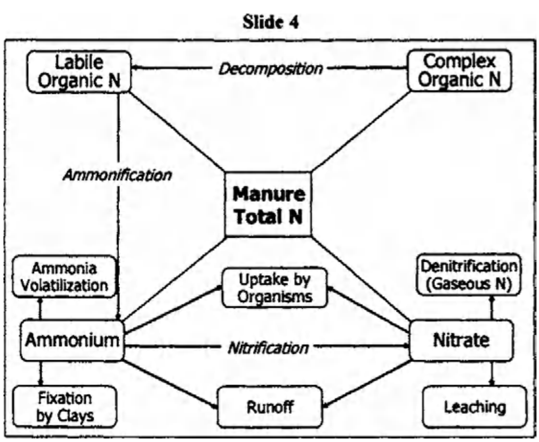


FIGURE A13.5

In addition to dealing with problems such as overloading individual slides with too much content or having too many word slides without appropriate photos, graphs, or other illustrations mixed in, consider the overall background design, color, size, and spacing.

A13.2 BACKGROUND DESIGN

A solid, usually white or a dark, cool color is a good choice. A simple shading of the background will not necessarily distract from the message, but any design that attracts undue attention to itself will subdue that message. Computer software now offers templates on which to put your words and data. Some of these are good; some would serve a marketer better than a scientist. With any background you select, be sure that the design does not overpower a text or other image you wish to make prominent. Note that if your institution or company requires that your background design include a standard logo, use it discretely in a position that does not interfere with the message.

A13.3 COLOR

Templates are also available for colors and color combinations, but if you use them, choose carefully. Note that the background design and especially the color can interfere with clarity of text in Figure A13.6. In Figure A13.7, the darker color makes the text more distinctive and easier for the viewer to read. Colors can also be customized, and these are often more fitting for your subject and your audience.

Generally, a dark background in a cool color (e.g., dark blues and greens) with light lettering in a warm but not bright color (e.g., off-white or pale yellow) will produce easily readable slides. Bright colors should be used in moderation to highlight specific points or to provide a focal point for the slide.

FIGURE A13.6

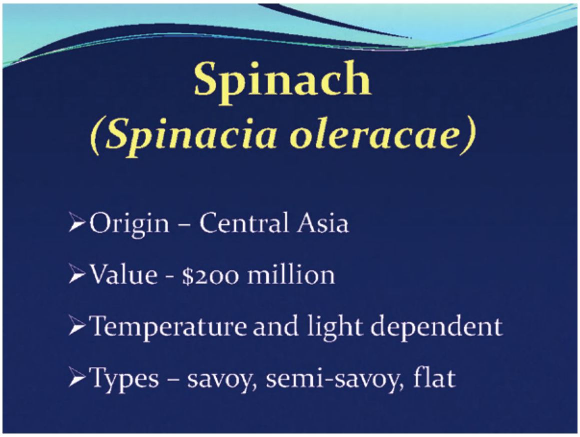


FIGURE A13.7

A13.4 SIZE AND SPACING

Size and spacing can affect both readability and attractiveness in a slide (Figures A13.7–A13.9). Let spacing help both with communicating the message and with doing so in an aesthetically pleasing manner. Do not overload any slide with images and words. To show more than two photographs on one slide is usually not good, and one is generally better. Overloading with words is detrimental to almost any message. To default to single or double spacing for an entire slide is not the best idea. Notice that in Figure A13.4, more space if left between the title and the text than within the text itself, but Figure A13.6 is single spaced throughout.

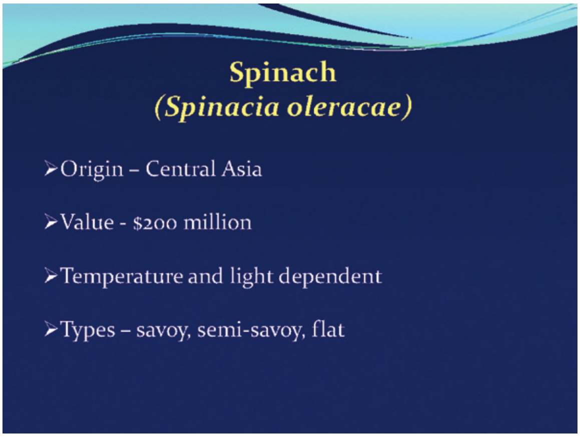


FIGURE A13.8

FIGURE A13.9

The slide set shown in Figure A13.10 was used in a presentation by Terry Gentry based on the preliminary study described in Appendix 5. The word slides serve as the outline for the speaker and contain only enough information to reinforce what he says to the audience. His repeated reference to the literature adds credibility to his own ideas about phytoremediation and microbial diversity in the rhizosphere. Notice how photographs are clearly related to the text and are mixed throughout the set to help convey the message and to provide relief from the word slides. His results are presented entirely with the table and two figures, which he can leave on the screen as he discusses the outcome of his study.

2

RHIZOSPHERE BACTERIAL DIVERSITY RELATIVE TO PHYTOREMEDATION OF ORGANIC CONTAMINANTS

Terry J. Gentry

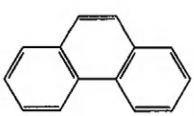
Department of Agronomy
University of Arkansas

3

PAHs

Polycyclic Aromatic Hydrocarbons

Phenanthrene



Pyrene

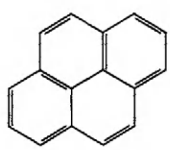


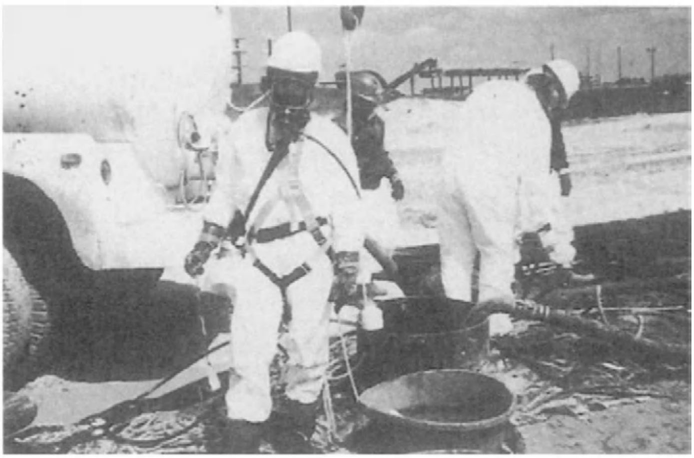
FIGURE A13.10

4

Pathways of Dissipation

- Volatilization
- Irreversible sorption
- Leaching
- Accumulation by plants
- Biodegradation

Reilley et al., 1996



6

Remediation Techniques

- Physical containment
- Excavation and treatment
- *In-situ* treatment

Lee et al., 1988

FIGURE A13.10 (Continued)

7

Factors Controlling
***In-Situ* Biodegradation**

- Soil water
- Oxygen
- Redox
- pH
- Nutrients
- Temperature

Sims et al., 1993

8

Bioremediation

- Use of living organisms to reduce or eliminate hazards resulting from accumulations of toxic chemicals and other hazardous wastes.

9

Phytoremediation

- Use of green plants to remove, contain, or render harmless environmental contaminants.

Cunningham & Berti, 1993

FIGURE A13.10 (Continued)

10

Phytoremedation

If pollutants are:

- Near the surface
- Relatively non-leachable
- Not imminent risk to health or environment

Cunningham & Lee, 1995

12

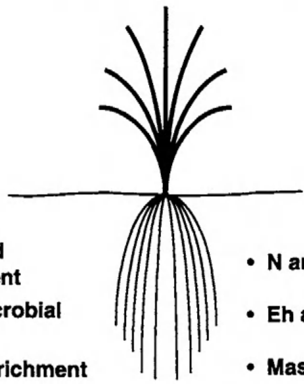
Rhizosphere

- Zone of soil under the direct influence of plant roots and in which there is an increased level of microbial numbers and activity.

Curl & Truelove, 1986

FIGURE A13.10 (Continued)

13



- C-enriched environment
- Higher microbial numbers
- Analog enrichment

- N and P availability
- Eh and pH
- Mass flow of water

14

- Increased density of microorganisms
- Increased biodegradation
- Increased diversity?

Anderson et al., 1995

15

- Soil bacteria are the primary degraders of PAHs.

Shabad & Cohan, 1972

FIGURE A13.10 (Continued)

16

Objective

- To assess the impact of the rhizosphere on soil bacterial diversity

17

Materials and Methods

- Captina silt loam and Appling sandy loam
- Bahiagrass and no plant control
- Growth chamber – 3 wk 16/8 h and 27/16 ±1°C

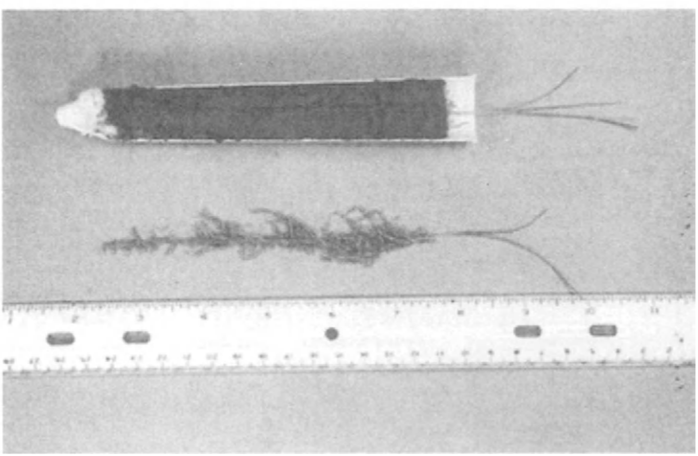


FIGURE A13.10 (Continued)

19

- **Total bacterial numbers**
- **200 random isolates**
- **Fatty acid methyl ester analysis (FAME)**

20

Total Bacterial Numbers

Captina silt loam			Appling sandy loam		
Bulk	Rhiz	R/S*	Bulk	Rhiz	R/S
--- 10^6 CFU/g dry soil ---			--- 10^6 CFU/g dry soil---		
10.0 a**	11.0 a	1.1	5.8 a	18.3 b	3.2

* Ratio of rhizosphere/bulk soil populations.
** For a given soil, numbers with the same lower-case letter are not significantly different at the 5% level.

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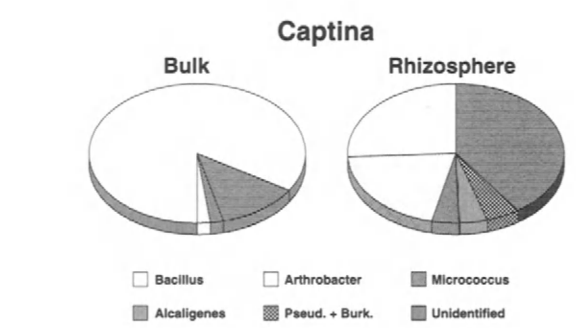
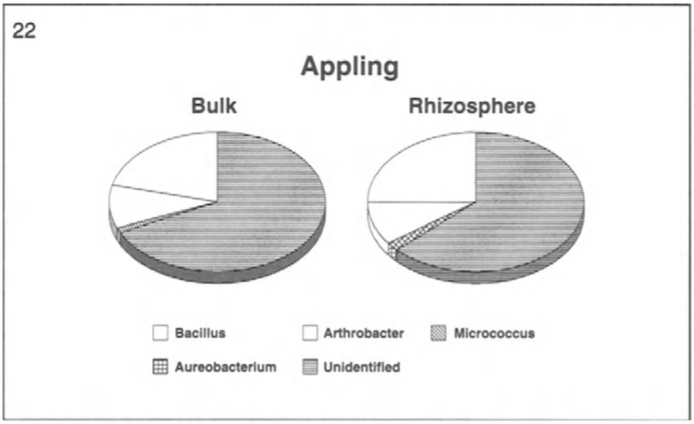


FIGURE A13.10 (Continued)



23

Conclusions

- Bahiagrass rhizosphere increased bacterial diversity in Captina silt loam.
- Diversity appeared different between soils.

24

- Increased understanding of the rhizosphere influence on bacterial populations may enhance remediation of PAH-contaminated soils.

FIGURE A13.10 (Continued)

Appendix 14

Oral Presentations at Meetings

When you read the following editorial, you may feel that Jay Lehr is being a bit severe in suggesting punishment by stoning for inept speakers. But after you have traveled several thousand miles to attend meetings to enhance your scientific and professional development and have listened to all too many speakers who waste your time with mumbling, reading, showing unreadable slides, or running long minutes overtime (perhaps into your own presentation time), then you may agree with Lehr's pronouncement. At least read the positive suggestions he makes to achieve a successful presentation; he hits upon the main ideas about the audience, the subject matter, the visual aids, and the speaker's delivery. Perhaps his stoning is facetious; his ideas for a good presentation certainly are not.

Editorial[1]
Let There Be Stoning!
by Jay H. Lehr

Let there be an end to incredibly boring speakers! They are not sophisticated, erudite scientists speaking above our intellectual capability; they are arrogant, thoughtless individuals who insult our very presence by their lack of concern for our desire to benefit from a meeting which we chose to attend.

We attempt to achieve excellence of written presentation in our journals. We can require no less in our conferences. It is an honor to be accepted as a speaker who will spend the valuable time of hundreds of scientists at a conference. Failure to spend this time wisely and well, failure to educate, entertain, elucidate, enlighten, and most important of all, failure to maintain attention and interest should be punishable by stoning. There is no excuse for such tedium, so why not exact the ultimate penalty?

Not long ago I became so enraged by a speaker at a conference I moderated, that I publicly humiliated him before 200 hostile attendees. This young

[1] Reproduced with permission from Marilyn Hoch, senior editor of *Ground Water*. This editorial by Jay H. Lehr appeared in *Ground Water* 23:162–165.

man chose to read in a monotone from a secretarial pad, flipping pages for 30 minutes of a scheduled 20-minute speech while complex slides tripped incomprehensibly across a screen behind him. At the conclusion of this group insult, he had the nerve to summarize his presentation, looking up for the first time, by stating that he hoped he had helped us to understand the relationship between the rain in Spain and the crumbling of the Rock of Gibraltar, or some such ponderous chain of reasoning. As I awakened the remaining audience, who had not the nerve to walk out as others had, I explained to the young man that he had done no such thing. Trembling as I spoke, I told him and the audience that his paper was an insult which had obviously bored and irritated a kindly group of scientists who deserved better. Those who kept awake refrained from stoning him, though they surely had adequate cause. The young man collapsed into his seat in shock as I proceeded with my vocal condemnation, the audience was pleasantly aghast, and this editorial was born.

What I said then I write now. It needs saying and writing. We have all experienced this insult, and many of us have been guilty of purveying it. It must stop. It is not funny. The penalty must be severe.

I recognized the problem when attending my first conference with my thesis advisor as a graduate student in the 1950s. I was appalled at the dreadful presentation I was subjected to. The professor tried to calm my immature ravings by explaining that all meetings were like this and that their value was in the halls, not the auditoriums. I could not see why value could not be attained in both places, but I have remained quiet too long. And so to begin.

The average conference paper is 20 minutes in length. It is not a college lecture where students are to absorb the minutest detail of a subject planned and presented as part of a 10 to 16 week curriculum. Rather, a conference paper offers an up-to-date capsule summary of a particular piece of ongoing or completed research for the purpose of bringing fellow scientists up to date on activities in their field.

A speaker cannot hope to teach the audience the specifics of his work, but he can elicit a valuable appreciation of the research effort and imply the value of the contribution to the growing body of knowledge on the subject. To achieve this he must convey enlightened enthusiasm for his subject and the advances he has attained.

Without exception a presentation with the aforementioned goals can and should be made extemporaneously. A scientist who cannot retain in his head the essence of his latest work can hardly be said to be enraptured by his subject. If a speaker is not excited enough by his area of expertise to weave it comfortably into the fabric of his cognitive thought processes, then how can he hope to excite an audience to an acceptable level of appreciation?

There is never an excuse to read a paper. True, it is the rare speaker who can articulate verbally the same elegant phraseology he commits to paper with the benefit of editing, but fewer still are the preachers of science who can bring the written word to life and the audience to the edge of their seats. Better to lower

the level of verbal excellence and raise the level of extemporaneous energy. The audience will never know what perfect phraseology they are missing, and the speaker must not allow himself to be frustrated by the inability to turn a perfect phrase in the air. In any case, a paper written for publication never reads well out loud. It's really a different medium. If the speaker excites the audience with his energy, they will want to read the paper later, and then they can rapture in the precision of the written word.

A few notes or an outline are all that are required to maintain order and organization. Slides, of course, can serve the same purpose, but never subject your audience to poor slides just because they serve as an outline for your talk. Poor slides are just a distraction from your hopefully vivid words. They must be brightly lit and convey a simple thought. If you need a pointer to indicate an important concept or location on a slide, it is probably too crowded or difficult to comprehend. If you can't read the print on a slide clearly with the naked eye (reading glasses are permitted) when holding it in your hand, it is inadequate for viewing with a slide projector in any size room with an adequately sized screen.

Never, but never (remember stoning) show a slide and then apologize for it. Don't show it. What did you think of the last speaker you heard say "I apologize for the poor quality of this slide," or "I realize no one past the front row can read this slide," or "I'm sorry you can't read the columns of numbers on this slide but I just wanted to point out …"? Point out what, fella—we can't read it, remember? Well, what did you think of these speakers? Dumb at best; *&!*&!*@*, at worst! Resist! Resist! Don't show bad slides! They never help; they always hurt. Don't be afraid to use no slides. Word pictures can be great if you practice painting them with a bit of rehearsal. Many of the best college professors you've heard do just fine in their lectures without slides. You can too—kick the crutch! But if you want to use slides, make them good ones. Good ones are not cheap. You can easily spend a few hundred dollars on a good set of slides for a talk, but look at the dividends:

—Your audience will sit up, take notice, and think you're great, someone special!
—You will invariably find many opportunities to use good slides over and over.
—Your audience paid good money to come and hear you. You probably got in free or at a reduced rate. Reinvest the savings in good slides and give your audience a dividend on their investment.

Don't stay on one slide too long; put blanks between slides if you have a lot to say before the next slide. The old slide is distracting. Don't let the slide lull you into a monotone; keep a high energy level with lots of enthusiasm. When you are giving a paper, you are an actor on a stage. You may be an incredible dullard in real life, putting people to sleep right and left, but at that podium, you're a star. You're an entertainer, an educator; put on a happy face and kick ass … or get off that stage. Science is sensational; working in

a factory is boring; seeking scientific truth is a turn on, so turn on or you'll turn your audience off. You ought to know, your colleagues have been doing it to you for years. Dare to be different. Use your hands, move around, not to the point of distraction, but look alive! Unless you're a pro and I'm boring you with the obvious, rehearse. Rehearse before a friend or relative and to yourself in the quiet of your mind, on a drive, a run, a swim, a cycle, a daydream, anywhere! Listen to yourself. Your wife, kids, and friends won't want to listen to you; bribe them, they will. If you tell them to be tough on you and let you know what's really bad, they'll love it. Think of the time the audience is collectively giving you. One hundred people times 20 minutes is 33 hours. Don't you owe them a few hours of effort in return?

Get your timing down. No one minds you going a minute or two overtime, but five or eight is inexcusable. Face it, there is extraneous material in your talk. You may love it, but the audience can do without it. Get to the point earlier, and spend more time on the meat and less on the soup and nuts. In the beginning, tell the audience what you're going to tell them. Then tell them, and be sure to leave time at the end to tell them what you told them. It sounds simple, but it works and they will appreciate it.

Make sure you talk into the microphone; tell the audience to let you know if you're too loud or not loud enough. You will lose 20 seconds regaining your composure and properly modulating your voice, but that beats 20 minutes of deafening silence or a rumbling sound system.

Avoid jokes unless you're a stand-up comic. Nothing is colder than a failed attempt at humor. If there is anything humorous in your subject, milk it. That's real and will be well received.

When all is said and done, more is said than done. Don't waste words, but if you must, remember that attitude is 75 percent of nearly everything in life; enthusiasm is at least that in public speaking. Brim with enthusiasm; if you don't have it for your work, how can an audience have it for you? Come alive!

A few words for moderators—you're the master of ceremonies, and you can set the tone for all of the speakers. Show an interest in the session. Open with 30 seconds of well-planned comments. Introduce each speaker with five pertinent points of information which you committed to memory in the past 10 minutes, i.e., college degrees and colleges attended, two significant past work affiliations (if pertinent), current work affiliation and activity focus. Do it like you know the speaker well, even if you never laid eyes on him before. You can do it. It takes just three minutes to learn five facts for a short duration. If you're not willing to put in the time, don't accept the job of moderator. When the speaker finishes, keep order during the question period and don't hog the microphone yourself, but do tie it all up with 30 seconds of concluding remarks, if appropriate. A good moderator can really help; a bad one gets in the way, wastes time, and impedes the performance of the speakers he is there to assist.

When on the speakers' platform, unless you have a natural wit and air of showmanship, you cannot afford to be yourself. You must be an actor who is

privileged to educate and entertain. The latter must come first or the former has no hope of attainment. But here is one simple rule that can make us surprisingly as comfortable before a group as with a single friend. Be intimate with your audience. Make them feel that you are there because you care about informing each and every one of them; no matter if there are 40 or 400, be intimate.

When you see the rare speaker who has an air of showmanship that allows him to get into the minds of his audiences, do you comment on how lucky the speaker is to be a natural? Are you sure you can't hope to emulate such a performance? A stage is meant to be acted on, whether to perform in a play or exhort a college student into a broader and deeper understanding of the subject at hand.

We have classrooms in college and stages at conferences because we know that the learning process can be enhanced by animated oral presentations which transcend the capacity to learn from the written page. Unfortunately, most of us achieve less, not more. We deliver an unenthusiastic reading or account which falls more deafly on ears than dead prose fall on our eyes.

Don't get up and do what comes naturally if what comes naturally is a dull, witless, monotonous presentation of unexciting facts. If your work is in fact dull and unexciting, don't burden any audience anywhere with a conference presentation. Publish somewhere if you must, if you can!

If, on the other hand, your work has substance that can be brought to life, do just that. Waste no more time saying you can't do it. Do it or have a colleague do it. There is no longer any excuse to be dull. Regardless of the fact that TV evangelists have given enthusiasm a bad name, be enthusiastic!

I studied astronomy under a dullard and thought it was a dead science. Carl Sagan taught me differently. I studied biology under a bore and saw no future in it in my mind. Paul Ehrlich showed me differently. My first economics professor put me to sleep, but Paul Samuelson awakened my interest.

I became a geologist because my earliest mentors, Cary Corneis, John Maxwell, and Harry Hess, made the earth live for me. Make your subject—no matter how esoteric—live for your audience if only for 20 minutes.

If everyone takes my message to heart, there need be no more public humiliations and even fewer stonings. But if egotistical, pompous, cavalier, obtuse, inconsiderate ignoramuses insist on ignoring these words to the wise, let there be stoning!

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Note: Page numbers followed by *f* indicate figures; *t*, tables; and *b*, boxes.

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